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PART 1: LEARNING SCIENCE CONCEPTUAL UNDERSTANDING

Co-editors: Roser Pinto and Kai Niebert

Theories, models, and empirical results on conceptual understanding, conceptual change and development of competences; methodology for investigating students' processes of concept formation and concept use; strategies to promote conceptual development.

This part corresponds to strand 1. It contains 16 papers.

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LEARNING SCIENCE CONCEPTUAL UNDERSTANDING

CHALLENGING PRE-GALILEAN MISCONCEPTIONS THROUGH ALTERNATIVE VISUALIZATIONS

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Abstract: While duly Copernican, a significant part of primary school teachers-in-training fail to see the point of the (Galilean) principle of relativity. Two inquiry based teaching sequences involving the notion of reference frame were designed to challenge the students' robust pre-Galilean misconceptions, without mathematical requirements. The first sequence makes use of an artist view ("Framed Earth", by Manchu, 1989) and literary representations of the Earth as seen from a lunar point of view. The second one deals with the succession of seasons through analogical models of the Earth/Sun system. Both sequences were tested among future primary school teachers. Half the cohort was only exposed to the latter sequence while the other half experimented both. Artist representations appear to be an effective way to challenge misconceptions where direct experimentation is not available, such as in astronomy problems.

Keywords: Frame of reference; Misconceptions; Principle of relativity; Artist view; Science fiction

INTRODUCTION

While scientifically closed for four centuries, the issue of heliocentrism still puzzles many a layman, to the point that it is now a common cliffhanger for journalistic discussions of scientific literacy. Many studies have established that a small but significant part of the population (typ. 20% — Gallup, 1999) still remain pre-Copernican, and bringing someone to admit that he believes in the Sun revolving around Earth has become a recurrent joke in mass media.

Pre-Galilean conceptions — namely, the existence of a privileged referential, whether heliocentric or geocentric — are even more widely shared. Saltiel (1980) has shown that for most students, "*proper motion and immobility are defined intrinsically, and not with respects to specified bodies and frames.* (…) *Motion and rest are thus fundamentally inequivalent, a typical pre-Galilean view*". Galilean relativity is classically taught through the mathematical exercise of changing the reference frame. Typically, one can then compare the apparent motion of Mars as seen either from the Earth or from the Sun. Students at ease with mathematical tools (namely spatial geometry) or with good spatial visualization skills (Kozhevnokov & al., 2007) thus integrate painlessly the Galilean paradigm, while otherwise bright students, typically of literary background but with a weakness in maths, often fail to even acknowledge the problem, ancient and conceptually simple as it may be.

This pedagogical difficulty is almost as old as Copernicanism itself. One strategy calls on one's "suspension of disbelief", through thought experiments and, more generally, fiction

(Picholle, 2006). It was first developed by Johannes Kepler to overcome the Ptolemaic prejudice. Kepler was probably first both to publish a formal mathematical analysis of the apparent motion of Mars (in *Mysterium Cosmographicum*, 1596) and, considering its public reception (or lack thereof), to try and bypass formalism through a *literary* thought experiment, the *Somnium* (*The Dream, or Lunar Astronomy,* written ca. 1609). Nowadays, while geocentrism is no longer a sensitive issue, estrangement (Parrinder, 2000) and extraction could still ease off the acceptation of an arbitrary point of view.

In the spirit of Kepler's strategy, the aim of the present study is to investigate the impact of contemporary fiction and artist views to help future teachers to overcome their own prejudices.

PRE-GALILEAN TEACHERS?

Many primary school teachers feel uncomfortable with the idea that, from a terrestrial point of view, the Sun rotates around the Earth. To quantify the prevalence of the Relativistic (*i.e.* Galilean) conception of the Solar system, we submitted 99 graduate students to a questionnaire: *"Two persons are discussing. One claims that the Earth rotates around the Sun and the other the opposite. They ask for your opinion. What do you answer? How do you know?"*

Fourteen different majors were represented, including twelve "experts" in physics (M1 of Master in Physics Teaching). All of them had theoretically been taught on the relativity of motion at least at secondary school level. If the Ptolemaic view is absent, the Copernican view is widely shared (> 90%) but seldom justified by scientific arguments: '*I learned it in school'* (26) / *'Because all planets turn around the Sun'* (18). On the other hand, the minority Galilean view (7/99) was always properly justified: '*Both can be said, it depends of the point of view*'. While physics "expert" students tended to favour the phrase "reference frame" over "point of view", only 1 out of 12 used it properly.

GRASPING RELATIVITY: GEOMETRY ISN'T ENOUGH

Two families of obstacles to the understanding of the Galilean paradigm by the students can be identified. One is technical (namely, mathematical), and associated to the capacity to juggle between points of view (Saltiel, 1980). But there is also a Bachelardian epistemological obstacle: *the reluctance to admit that all reference frames can be equally legitimate* (associated or not to a "natural locus"-like Aristotelian prejudice), even when one can juggle between different points of view.

Our hypothesis is than the latter (epistemological) obstacle is involved in the rarity of the Galilean view. Specific work on the physicality of alternate points of view is thus necessary to overcome it.

METHODOLOGY

The training of future primary school teachers normally includes a inquiry-based learning sequence on Astronomy, involving a discussion of the relative position of Earth and Sun through the traditional problem of the succession of seasons on Earth.

We followed the example of Kepler's *Somnium,* in which a narrator describes his trip on the Moon. Looking through his eyes, the reader is then brought to accept the Lunar point of view as physically legitimate. We designed inquiry sequences implementing this idea through contemporary science fiction works, both literary excerpts and artist views.

In combination with a sequence on the spatial relationships involved in Earth seasons, emphasizing their geometrical reciprocity, they allow to tackle both obstacle families.

"Framed Earth" sequence

The "Framed Earth" sequence (Blanquet, 2011) first involves a painting from French artist Manchu (1989), reproduced in Fig. 1.

Manchu's realistic art suggests a stationary Earth in Moon's sky and raises questions: *Does the Earth stay in the frame? Can Moon's inhabitants observe all the parts of the Earth? Do they see Earth' phases? Where are they on the Moon?* Using their previous knowledge about the Moon, students can conclude with adequate questioning and reformulations from the facilitator. During the process, corporal motions and direct visualizations of analogical models facilitate the representation of several Lunar points of view, thereafter readily accepted as legitimate.

Fig. 1: "La Frontière éclatée"

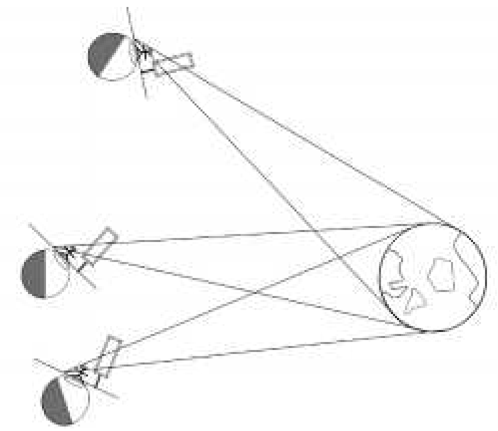

Fig.2: Schematic explanation of the Earth remaining in the Frame

Additionally, excerpts from short stories allow independent tests of students' views through distinct thought experiments: they have to identify hints of Earth's appearance and behaviour and to check them against what they had discovered during the course. They were also brought to discover how Earth's terminator could be used as a clock from the Moon.

A typical excerpt reads:

> 'Like all the best hotels, the Zurich is in Pressure One on the west side so that it can have a view of Earth. I helped Miss Brentwood register with the roboclerk and found her room; it had its own port. She went straight to it, began staring at Earth and going ooh! and ahh! I glanced past her and saw that it was a few minutes past thirteen; sunset sliced straight down the tip of India — early enough to snag another client. "Will that be all, Miss Brentwood?" (…) The view on that side is monotonous except for Earth hanging in the sky.' (Heinlein, 1957)

"Seasons" sequence

Since few primary school teachers-to-be have an advanced scientific background, the usual astronomical sequence also avoids mathematic difficulties by using analogical models (polystyrene balls to represent the planet, etc.) and bodily motions.

Taking into account the phenomena visible from Earth (apparent motion of Sun and stars), the trainees have to propose different models and to discuss their validity, without ever using either the common sense or the authoritative arguments. Alternating points of view, they are brought to acknowledge the geometrical reciprocity of various solar system models and to reconsider their position about the relativity of the motion of Earth and Sun. Previous acceptance of the legitimacy of the Lunar point of view strengthens the physical legitimacy of terrestrial point with regards to the heliocentric one.

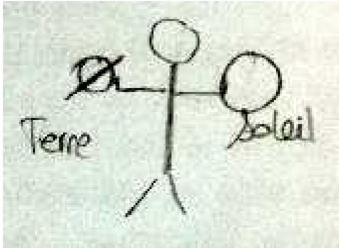

Fig.3: Inclining the Earth' axis to explain alternate seasons in Northern and Southern hemispheres (student drawing)

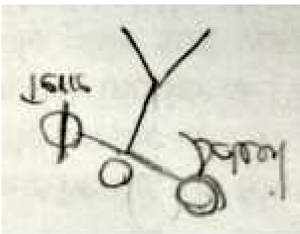

Fig.4: Same as Fig. 3. Inclining the Sun (alternate explanation from the same student)

Assessment methodology

The same questionnaire as above was submitted to a second group of 93 students (M1 Master of « primary school Teaching », none of them Physics majors) after they experienced the "Framed Earth" sequence (with teacher A). They then experienced the "seasons" sequence. Two weeks later, a more detailed questionnaire including slightly different formulations of the same question was asked for comparison (with two different teachers A and B). All sequences were audio- and video-taped for transcription and analysis.

DESTABILISATION OF MISCONCEPTIONS

The “Framed Earth” sequence alone doesn’t appear to significantly affect students’ initial conceptions. In combination, the two sequences appear to yield significant progress towards the Galilean paradigm. No dependence on student’s previous major was observed. Yet, while further studies would be necessary to assess the robustness of this approach, available results suggest that it may be significantly teacher-sensitive method.

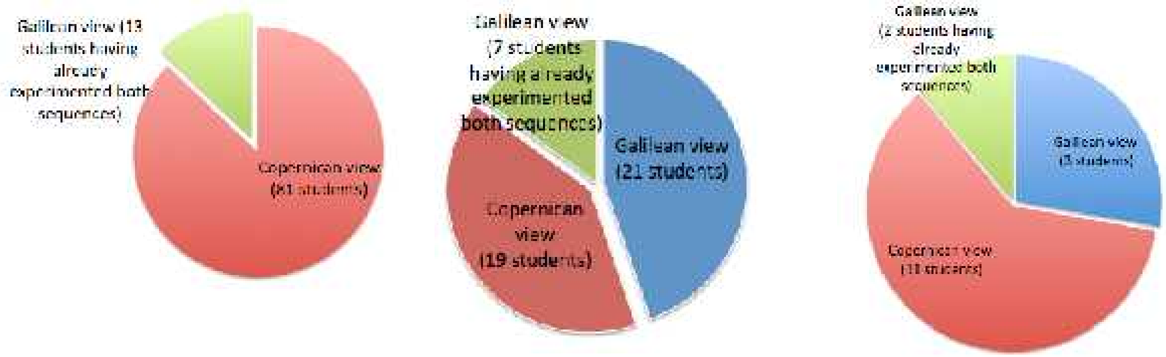

Fig.5 (a): Students’ view after the “Framed Earth” sequence only (93 students) **(b) *idem* after both sequences (Teacher A, 47 students)** **(c) *idem* Students’ view after both sequences (Teacher B, 18 students)**

CONCLUSION

Artist representation appears to affect the expression of paradigmatic misconceptions and to contribute to modify them, at least in this specific case. Considering the robustness of pre-Galilean misconceptions, this is already a significant step. The cognitive processes involved in fiction thus appear as a promising (albeit not autonomous) tool to help overcome epistemological obstacles related to physicality. The ability to imagine oneself in another frame of reference, using artist’s visualization also seems an efficient alternative to introduce the principle of relativity to a public without regard to it mathematical literacy.

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CONSTRUCTING SCIENTIFIC KNOWLEDGE IN THE CLASSROOM: A MULTIMODAL PERSPECTIVE ON CONCEPTUAL CHANGE

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Abstract: Constructivism remains one of the most influential approaches to understanding how children learn in science. Research investigating learning from this approach has led to the development of a wide range of models that aim to explain the underlying processes of how concepts change from alternative explanations of phenomena to those that are scientifically acceptable (Vosniadou, 2008). These models of conceptual change range in their depth and scope with some attributing change to purely cognitive processes (Rumelhart & Norman, 1978) whilst others suggest a role for motivation and affective factors (Pintrich et al, 1993). In addition, contemporary research has begun to explore the links between the role of practical activity, skills development, language, and non-verbal behaviour such as gesture in the development of new concepts and the restructuring of those already held (Crowder & Newman, 1993). This study utilises a cross-sectional design in order to explore the development of science ideas and concepts related to electricity and floating and sinking in children aged 7, 11 and 14 years in English classrooms. The study adopts a new and innovative multimodal approach that combines practical science activities alongside interview and observational protocols together with the addition of gesture analysis. The results from this study form the basis of a critique intended to re-evaluate and inform the debate resulting from different models of conceptual change.

Keywords: Learning in science, constructivism, conceptual change, multimodal research, gesture

INTRODUCTION

Constructivism remains one of the most influential contemporary approaches to understanding how children come to learn science in school classrooms. The constructivist perspective maintains the view that children will have formed some representations of many of the phenomena studied in school science based on their previous experiences and reflection on those experiences in order to understand the world around them (Driver, Asoko, Leach, Mortimer & Scott, 1994). These initial representations are proposed to take the form of 'alternative frameworks' because of the explanatory scope that they provide children with. These 'alternative frameworks' contain conceptual understanding that frequently contrasts with scientific explanations of the same phenomena and therefore they are subject to change when children begin their formal science education (Driver & Easley, 1978; Driver & Bell, 1986). Research investigating learning from this perspective has led to the development of a number of explanatory models identifying underlying mechanisms that support such 'conceptual changes' (for example Vosniadou & Brewer, 1987; diSessa, 1988; Sharp & Kuerbis, 2006, summaries in Vosniadou 2008; Limon & Mason, 2002). These models range in their depth and scope with some placing a high emphasis on purely cognitive processes (Rumelhart & Norman, 1978; Posner, Strike, Hewson & Gertzog, 1982) whilst others attribute a strong role to motivational and affective factors (Pintrich, Marx & Boyle, 1993, Dole & Sinatra, 1998). While the work presented here does not debate the influence that affective factors may have on children's learning it asserts that the current level of diversity between the cognitive models of conceptual change is unhelpful to both teachers and researchers not least of all because it restricts the pragmatic incorporation of key ideas into everyday practices. In addition, however, research associated with each individual model of conceptual change focuses on single areas of scientific phenomena. Vosniadou's weak and radical restructuring for example draws the majority of its evidence from astronomy teaching (Vosniadou & Brewer, 1987). Biology concepts are the focus of Carey's (1985) weak and strong restructuring model. And the development of ideas of force studied in physics is the focus of diSessa's fragmentation theory (1988). Models also frequently lack consistency between the ages of participants recruited, notably diSessa's original contributions from college students whereas Vosnidou's research recruited school age children. One criticism that is more fundamental originates from the lack of consensus regarding the level of mental representation studied. In some cases the aim is to study individual concepts and in others mental models which result from theory structures are utilised. Taken as a whole, this diversity of subjects studied restricts comparison and evaluation of models across scientific domains and prevents the models being evaluated for their utility in informing teaching across scientific curricula. In order to overcome these difficulties the work presented here evaluates the models within comparative contexts in two science domains, notably in the development of children's ideas in electricity and floating and sinking (the Archimedes principle).

Contemporary literature typically approaches the assessment of conceptual knowledge through verbal reports that are accessed through interviews or task-based activities (Osborne & Freyberg, 1985; Primary Space Projects, 1990/1994). Whilst this approach has been successful for generating a wide body of understanding regarding the knowledge that children hold, the bias towards language and linguistic capabilities may prevent a comprehensive understanding of children's knowledge particularly if children are not able to clearly or fully articulate what they know (Goldin-Meadows, 2000). In order to overcome this potential bias, the work presented here investigates the development of scientific ideas and concepts from a multimodal perspective. The multimodal approach to understanding children's learning is a new and innovative research area but one developing rapidly. Initial findings from wider research adopting this approach have demonstrated that during the course of their learning children utilise a number of different expressive modes in order to acquire conceptual knowledge. These modes include verbal dialogue, written pieces, drawings and other expressive art forms and non-verbal communication such as gesture, eye gaze and body posture (Kress et al, 2001). Whilst Kress et al's research focused on how different modes of activity support children's acquisition of concepts in science other researchers (for example Goldin-Meadows, 2000) have investigated the role that non-verbal language such as gesture has in revealing children's existing conceptual knowledge. One early analysis conducted by Crowder and Newman (1993) investigated the gesture and speech of thirteen children who were learning the science concepts associated with seasonal change. The results revealed that some gestures were 'redundant', others served to enhance the ideas expressed through speech, and in some cases gestures served as carriers of scientific meaning that was not present in language.

This led Crowder and Newman to conclude that "*as long as ideas outstrip scientific vocabulary, one can expect to see gestures used by elementary science students to carry unstated ideas"* (p.176). In a summary paper that drew on a body of research investigating different areas of children's problem solving ability Goldin-Meadows et al

(1993) suggest that stability between speech and gesture characterise a stable understanding of a concept, mismatch between the two elements characterises the time in which children are moving between conceptual understandings. It was argued that the "*gesture-speech mismatch signals to the social world that an individual is in a transitional knowledge state"* (Goldin- Meadows et al, 1993, p.279). This was a particularly attractive idea for the work undertaken and presented here as it highlights a window of opportunity through which it may be possible to capture the processes of conceptual change as it actually occurs. It is proposed that this method enables a more comprehensive exploration of how conceptual understanding develops.

The work presented here discusses an initial analysis of findings from an ongoing doctoral level research project currently in the main data collection and early analysis phases.

RATIONALE

This project specifically investigates the following research questions:

- how and to what extent do multimodal analyses of children's verbal and non-verbal communication facilitate understanding of the science ideas and concepts that children have;
- to what extent can such analyses be utilised in order to explore and understand the dynamics that support conceptual change?

METHOD

The research presented here utilised a cross-sectional design by studying the scientific ideas and concepts of three groups of children aged seven, eleven and fourteen years in English Primary and Secondary schools. A total of 101 children took part in the study, the children were distributed as follows across the three age groups; 34 aged seven, 44 aged eleven and 15 aged fourteen. All of the children participating in the study completed two practical science activities, one in electricity and one in floating and sinking. The practical activities were designed to elicit children's ideas by probing understanding as they completed familiar tasks (for example, the construction of simple circuits) whilst subsequent tasks were designed to challenge existing ideas (for example, an analogy of electron movement in a simple circuit using 'smarties'). These activities permitted the analysis of both existing ideas and concepts and the opportunity to observe the outcome when concepts begin to change or are challenged.

The practical science activities took place in small groups (approximately five children of the same age in each group). The activities were highly contextualised to the concepts studied, interactive and dialogic in nature and included protocols from participant observation and interview based methodologies. Each practical science activity lasted approximately one hour. All were audio-video recorded in order to capture events fully and to obtain gesture in transmission.

In order to explore the potential role of each response type the transcription and the subsequent analysis focused on the modes and areas shown in figure 1.

Levels of Comparison
Between Activities
Between Age Groups
Between Participants
Between Individual Groups

Levels of Analysis
Analysis of Verbal Responses
Analysis of Drawing
Analysis of Written Responses
Analysis of Gesture and Non-verbal Responses
Analysis of Social Interaction
Analysis of the Activity

Figure 1: The different levels of comparison and analysis explored in the study.

Transcripts coded both verbal and non-verbal responses collected throughout each of the activities. Analyses of the data included both within and between age group comparisons for children's ideas and concepts related to each of the science topics. Verbal and non-verbal data were interpreted using a content analysis approach and analysed in order to capture matches and mismatches between the two forms of communication.

RESULTS

Although this project is still in the early stages of analyses the results are beginning to reveal important information about children's gestures. Our data demonstrates that children use five different types of gesture, these gestures contain both scientific and social information (Callinan & Sharp, 2011) figure 2 below provides an overview of the types of gestures.

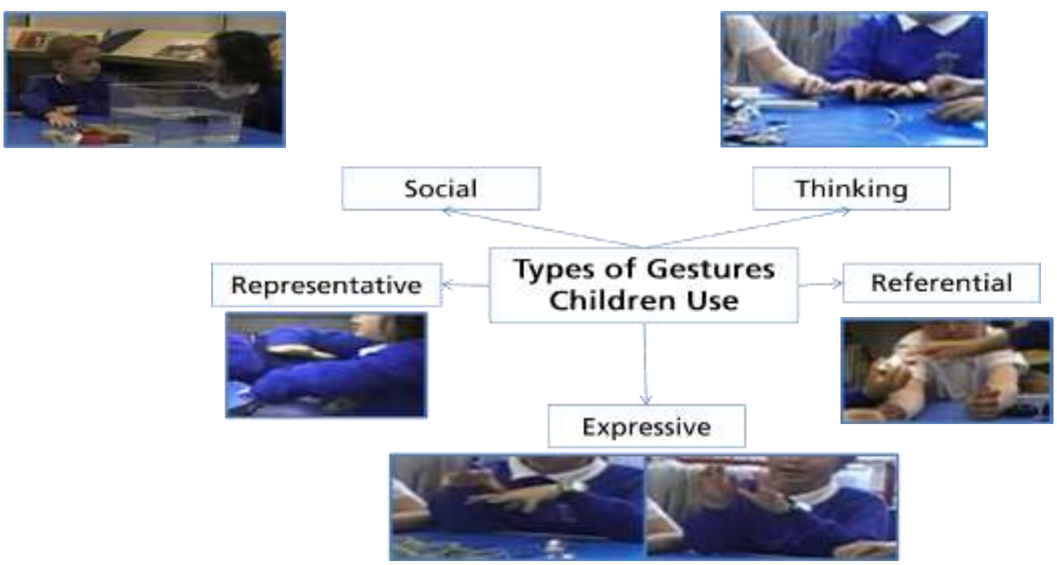

Figure 2: The types of gestures that children use when completing practical science activities and discussing their ideas (Callinan & Sharp, 2011).

Scientific gestures came in four main forms:

- referential – e.g. pointing to objects, pictures or people in the immediate environment;
- representative – e.g. re-enacting the behaviour of objects, pictures, or people;
- expressive – e.g. often including repetitive movements or building on representative gestures revealing the values associated objects, pictures or people;
- thinking – e.g. finger drumming, waving hands, head holding or face and hair stroking.

While scientific gestures appear to play a crucial role in facilitating our understanding of children's scientific ideas, social gestures also have an important role for facilitating our understanding of how young children use input from peers in order to structure their responses to probes of knowledge or seek social support when they are experiencing uncertainty or difficulty in generating a response. During the course of this study there are many instances which demonstrate how children have used such non-verbal approaches to eliciting help from each other. In one example, 'Daniel' (7 years old) used a social gesture whilst discussing his ideas related to floating and sinking. As he spoke Daniel he paused mid- sentence, moved his head to look in turn at each of his neighbours, and after receiving no response from them, he continued to speak. This gesture was interpreted as Daniel's non- verbal way of exploring whether these was agreement for his ideas within the other members of the group. Whilst these gestures can be interpreted as demonstrating little information regarding children's scientific understanding they are particularly helpful for revealing how children negotiate meaning in groups.

Early analyses investigating the possible match – mismatch between verbal and non-verbal communication revealed that for children who produce non-verbal gestures these can contain valuable information regarding their ideas that are not included in the verbal responses. For example, analyses of path tracing during discussions of electricity circuits demonstrated non- verbal clues to children's underlying mental models that may not be reflected in what they say. Our data demonstrates that although children frequently give similar verbal response, for example, 'the electricity flows through the wires to the bulb', the children draw three distinct forms of paths to represent this 'flow' of electricity in the circuit. Some children use one hand to draw a path that begins at the battery and follows the wire before stopping at the bulb. Other children use one hand to draw a path that begins at the battery, follows the path of the wire to the bulb before continuing around the second wire and stopping at the battery. Finally, some children use both hands to draw a path that begins at the battery, each hand then follows a different wire until they meet at the bulb and stop there. This final example is resonant of the 'clashing currents' model discussed in the research literature (Osborne et al, 1991). It is proposed that results such as these support the need for a more detailed analysis of children's gesture and support the view that children's gesture can indeed reveal vital information about children's ideas in science.

The between subjects analyses demonstrated that children's ideas regarding scientific phenomena change over time and become increasingly more scientific. For example, the children aged 7 years initially demonstrated an object-centred understanding of the scientific phenomena associated with floating and sinking. This initial understanding is biased towards the size and weight of the object being explored. The children aged 11 years still possessed object-centred frameworks, however their discussions expanded to include factors of weight, size and properties of materials, thus demonstrating an early understanding of the concept of density. It is only at 14 years that the children began to consider a range of other variables that may have influenced whether objects float or sink, for example the behaviour of the liquid in which the object is placed.

The analyses also revealed that when existing ideas are challenged through practical science activities some children begin to immediately incorporate the new ideas into their existing schema whilst others appear more resistant to the new explanation. Changes in ideas can be observed in the children's verbal responses following participation in the activities, however, in some cases the change in ideas can also be observed in the gestures that children produce. In one example drawn from our floating and sinking activities Sam (11 years old) demonstrates a change in his non-verbal gestures following the challenge of his ideas. At the beginning of the activity Sam's gesture related to his ideas of sinking was as follows, he used his left hand, which was held flat with the palm facing downwards, to make a downward sweeping motion. After Sam's ideas had been challenged through our demonstration of upthrust and water displacement his gesture changed so that his hand was held in a 'c' shape with the palm facing upwards and he used this hand to made a downward movement. This change in gesture appears to illustrate a change in Sam's ideas regarding the forces involved in sinking. His initial gesture appears to indicate that he locates the force which makes the object sink as acting from above. However, after of our discussion of upthrust his gesture is altered so that it reflects the supportive force that is located from beneath the object. His verbal explanation afterwards also contained more complex information and he stated that sinking is "the gravitational pull, pulling something heavy under water". Further analysis of data such as this will be used in order to investigate whether our results can support any of the current models of conceptual change.

CONCLUSIONS

It is proposed that the multimodal, task-based approach presented here offers a more comprehensive route for studying children's existing ideas and concepts of the scientific phenomena associated with electricity, and floating and sinking and probably all phenomena by extension. It is also suggested that verbal analyses of children's responses to probes regarding their ideas used in isolation are insufficient on their own and can lead to biases in results that may fail to account for children's actual knowledge and result in the misclassification of the underlying frameworks that the children hold. The multimodal approach is particularly helpful for understanding younger children's ideas especially when they find it difficult to articulate their ideas and concepts coherently or fully.

In addition, our early analysis suggests that different types of gesture may have different functions and an understanding of these can further our understanding of what children know and can do. It is also suggested that the research presented here highlights the requirement for further similar studies with different groups of participants, for example, further investigation is necessary in order to understand the way in which older participants may use multimodal representations when explaining their science ideas. Such research should ideally explore a range of participants including post G.C.S.E., A level and H.E. students as well as student teachers and lecturers. By exploring the way in which gestures are used to complement and extend verbal explanations of science concepts and ideas it may be possible to better understand how knowledge of science is communicated and it is suggested that this might have implications for assessment, pedagogy, and curriculum development.

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STUDENTS' LEARNING PROCESSES IN THE FIELD OF SPECIAL RELATIVITY.

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Abstract: A major topic that has marked "modern physics" is the Theory of Special Relativity (TSR). The present work focuses on the possibility to teach and learn basic ideas of the TSR in the upper secondary school. Its aim is to investigate students' learning processes towards the two axioms of the theory and their consequences, namely the relativity of simultaneity, time dilation and length contraction. Based on a teaching and learning sequence, developed specifically for this study, five sets of interviews were conducted with forty 10th grade students (aged 15-16). The interviews were oriented to the so-called "teaching-experiment". The results show that upper secondary education students are able to cope with the basic ideas of the TSR. There are some difficulties though, related to the following students' conceptions: a) There is an absolute frame of reference, b) equivalent observers are identical and there is a privileged observer and c) objects have fixed properties. These difficulties seem to be reinforced by the way school science is taught, which provides students with a 'cognitive framework' based on Newtonian mechanics.

Keywords: Special Relativity, Upper Secondary Education, thought experiment, learning processes, teaching experiment.

BACKGROUND, FRAMEWORK AND PURPOSE

The Theory of Special Relativity (TSR) is one of the most significant scientific advances of the 20th century which has changed our understanding of the physical universe. It suggests that the physical world is relativistic, in the sense that measurements of time, space and mass depend on the relative motion of the object and the observer (Shabajee & Postlethwaite, 2000). Space and time cannot be separated from each other; they are part of a single entity, spacetime (Taylor & Wheeler, 1991, p.7). However, it still leaves us with a deterministic view of the physical universe in which variables are related in such a way that a change of one variable produces a definite and predictable change in another dependent variable (Shabajee & Postlethwaite, 2000).

Science Educators recognize the pedagogical value of this topic, since it gives rise to a new form of looking at the extremes of the natural world, namely the extremely fast (Arriassecq & Greca, 2010). Science education research in this field deals with students' understanding of basic ideas of TSR in the university level (e.g. Hewson 1982; Scherr 2001) and in the secondary level (e.g. Borghi et al., 1993; Guisasola et al., 2009).

This research shows that students hold pre-Galilean notions as far as *motion and velocity* are concerned. In particular, motion and velocity are recognized as physical properties of the moving object, independent of observers (Saltiel & Malgrange, 1980). As a result, students do not define the velocity of a body with respect to a frame of reference (O' Brien-Pride, 1997 in Scherr, 2001).

Students tend to consider the *frame of reference* as a “decorative ploy” with no explanatory purpose (Panse, Ramadas & Kumar, 1994). The inertial character of a frame of reference is considered to be a ‘relative’ property, rather than an intrinsic one (Ramadas, Barve & Kumar, 1996) and the term is used as a ‘magic word’ because it does not have any specific interpretative function for them (Pietrocola & Zylbersztajn, 1999).

As far as the *speed of light* is concerned, students do not realize that it is invariant. They admit that the speed of light is constant, but this stems from the idea that speed is absolute generally and it is not specified with respect to a frame of reference (Villani and Pacca, 1987).

In addition, students believe that there are ‘*privileged observers’*, with immediate access to the ‘proper’ values of spatial and temporal parameters which characterize the motion (Hosoume, 1986 in Villani & Pacca, 1987). Thus students violate the *Principle of Relativity,* since they do not consider the observers equivalent.

Furthermore, *time dilation* and *length contraction* are considered as optical illusions (Angotti et al., 1978) or “distortions of perception” (Hewson, 1982). Thus students are reluctant to accept them as real.

Taking these findings into account the present work focuses on the possibility to teach and learn basic ideas of the TSR in the upper secondary school. The aim is to investigate students’ learning processes towards the two axioms of the theory and their consequences, namely the relativity of simultaneity, time dilation and length contraction.

METHODOLOGY

Based on an educational analysis of the science content structure of TSR (Dimitriadi & Halkia, 2010) and a pilot study (Dimitriadi, Halkia & Skordoulis, 2009), a teaching and learning sequence was developed. The empirical investigation was designed as a learning process study. In order to collect the data, interviews and two questionnaires (one before and one after the interviews) were used. The interviews were oriented to the so-called ‘teaching experiment’, which has been applied with success in order to investigate students’ learning processes in new fields (Katu, Lunetta & van de Berg, 1993; Stavrou, Duit & Komorek, 2008). Teaching experiment may be viewed as Piagetian critical interviews deliberately employed as teaching and learning situation. The interviewer assumes both the roles of a ‘classical’ interviewer, who tries to interpret the students’ individual conceptions, and of a teacher, who must have answers to students’ conceptions and make the appropriate intervention at just the right moment (Komorek & Duit 2004).

Forty students of the upper secondary school (grade 10; age 15-16) took part in the investigation. The students were divided in 10 groups (with 4 students each). Five sets of interviews (with a time interval of 1-3 days between them) for each group took place. Every set lasted approximately 60 minutes. The main points of the interviews were:

1st Interview - The first axiom of the TSR (The Principle of Relativity): Students were expected, using everyday examples, to come to the conclusion that there is no way to realize if they are moving with a constant speed or not, so these situations are equivalent.

2nd *Interview - The second axiom of the TSR (The Invariance of the Speed of Light):* Students should conclude that the speed of light is constant and invariable using a thought experiment, where two observers in a train measure the speed of the light when the train is not moving and when its motion is uniform

3rd Interview - The relativity of simultaneity: Students had to handle the relativity of simultaneity using the thought experiment "Einstein's train paradox".

4th Interview - The relativity of time: Students had to come to the conclusion that time is relative using the "light-clock" thought experiment.

5th Interview - The relativity of length: Students should conclude that length is relative as well. The thought experiment used in this case was about two observers who move relative to each other and conduct different length measurements.

The first author carried out the interviews, which were audio taped and transcribed. Due to the explorative character of this study methods of qualitative content analysis were applied (Erickson, 1998).

RESULTS

The main findings of the study show that students are able to recognize the basic ideas of the TSR and to deal with its consequences which have to do with the relativity of time and space.

They face some difficulties though, since they believe that a) there is an absolute frame of reference, b) equivalent observers are identical and there is a privileged observer and c) objects have fixed properties. Students' conceptions and their learning processes are presented analytically in the following:

a) Frame of reference

Trying to define whether they are moving or not, students do not realize that motion is a relative property. Thus, at the beginning, when they try to define if they are moving, they do not use reference points at all.

Student B2: We are moving when we change our position.

When they start using reference points in their answers, they tend to choose objects which are fixed to the ground. They argue that we cannot use as a reference point a moving object:

Student F3: We cannot use the car as a reference point

Student F2: Unless it is in the parking.

Some points of reference are 'more appropriate' according to the students. They imply that actually there is a privileged frame; the ground's frame of reference. Even when they change frame of reference and they use the sun instead of the ground, they keep determining the motion with respect to the sun exclusively. So students believe that motion is not a relative property depending on the chosen frame of reference. Instead they believe that it is absolute.

As a consequence, they argue that velocity is also absolute and it becomes a property of the moving body.

Student J2: Velocity is standard. It is not a force to add or to subtract. It is v, it doesn't change.

To face this idea, in the first session a number of examples were discussed, where students had to deal with several points of reference. It was considered crucial that students should start handling problems with frames of reference beyond the ground's or the sun's frame of reference. So they elaborated problems which took place in a ship, in an airplane, on another planet etc.

An interesting point is that the alternative idea that velocity is absolute seems to lead to the right conclusion as far as the 2nd axiom is concerned. Students argued that light has its “natural” speed, which is constant. At the same time though, they answered that the observers’ measurements could be different.

Student B2: Light has always the same speed. What the observers measure... well, this depends on how fast they are going.

So it was important to deal with the fact that velocity is defined with respect to a frame of reference, in order to realize light’s special properties.

b) Observers

Applying the first axiom, a problem arose from the way students perceive the concept of equivalence. They believe that equivalent observers conduct identical measurements. This causes some difficulties when dealing with the relativistic effects, since students argue that the observers should make the same measurements and the same observations.

Furthermore, dealing with relativistic effects, they implied that there is a privileged observer, usually the one who stands on the ground and in some cases at a specific point

Student B1: I believe that the observer who is not moving is the best. Because in your daily life when you are standing still you have plenty of time to observe something.

Student E4: Does the observer have the right position? Is he in the middle?

In addition, students believe that what differentiates the observers is not only their relative motion, but also that they have different position. This idea came up mostly when they dealt with the relativity of simultaneity; they associate the time of an event with the time at which an observer receives a signal from the event, as also Scherr, Shaffer and Vokos (2002) point out. Although it was made clear to them that we are referring to intelligent observers, who are able to elaborate their observations in order to come to a conclusion, students were not able to realize that the observers’ different position does not differentiate the results.

It seems that students believe that events happen independently of what the observers perceive. There is a ‘privileged’ observer though, the one who stands at the ‘right point’. As a result, this observer perceives the facts as they really happen.

Student E2: In nature, things happen only once. What a person sees or feels is something different.

This idea was confronted by laying emphasis on the Principle of Relativity. The fact that they had to apply the first axiom in order to answer to the question “Who is right” whenever the observers conducted different measurements, helped them to realize that there is no privileged observer since they are equivalent, according to the TSR’s first axiom.

c) Objects Properties

Dealing with the relativity of the length, students have strong objections. It seems more difficult for them to accept this relativistic effect comparing to the relativity of the time, as length is considered as a “property” of the things in itself; thus it cannot change. Time on the other hand is not associated to objects, so it could have a subjective character. At the same time, students show their commitment to a mechanistic view of the world in which objects have fixed properties such as length, mass etc. as Hewson (1982) has pointed out.

Student C3:	It is not possible. 20cm are 20 cm. They are neither 15, nor 35...
Teacher:	Respectively, 5sec are 5sec...
Student C3:	This is different...
Teacher:	Why?
Student C3:	Time is something else... Time is relative

In order to face this difficulty, emphasis was laid on the fact that both the relativity of time and the relativity of length are consequences of the invariance of the speed of light. The thought experiment with the "light clock" helped them to make this connection; using the time measurements, they were able to find the length of an object. So they concluded that if time is relative, length is relative as well.

CONCLUSIONS AND IMPLICATIONS

This study offers an insight into upper secondary students' learning processes about Special Relativity. It shows that students in this level are able to realize the basic ideas of the theory and to deal with its consequences relevant to the relativity of time and space. Specifically, they deal with problems which are in contrast to their everyday experience effectively, and they started questioning about their privileged position in the Universe, which is a very important aspect in their way of thinking

Student:	The observer does not realize the relativistic effects, because he deals with the facts from his point of view. He doesn't know that we have a different opinion... But our opinion is not better than his...

Nevertheless, they restrict TSR's validity in the way the observers perceive the events or conduct measurements. They seem to try to incorporate the Theory of Relativity, to Classical Physics. Their ideas seem to be the "product of Einsteinian branches grafted to Newtonian roots" (Hewson 1982).

The results of the present study lead to the conclusion that students seem to think with absolute terms. What we should consider, is how the teaching of school physics influences their way of thinking; it seems to reinforce these problems. Especially, the way students have been taught classical mechanics; the idea of absolute motion is deeply rooted in their thinking. So it is important in the secondary education to liberate students from the idea of an absolute frame of reference (Villani & Pacca 1987). Moreover, "by providing children with a 'cognitive framework' derived from Newtonian mechanics and presenting this both as unproblematic and all-powerful (when we know that...it is fundamentally incorrect) we are taking steps designed to make any subsequent learning of 20th century relativistic ideas completely difficult" (Shabajee & Postlethwaite, 2000).

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REASONING SCHEMATA ACTIVATED BY SECONDARY EDUCATION STUDENTS IN ORDER TO SOLVE CHEMICAL KINETICS QUESTIONS

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Abstract: this research is part of a broader one in which the influence of a teaching proposal about Chemical Kinetics on the learning of 4th grade of Compulsory Secondary Education (15 to 17 years old) students has been studied. In this paper the initial characterization of the sample is described. In order to achieve this, we have designed the reasoning schemata *speed of reaction* activated by the students when answering the proposed questions.

Keywords: Reasoning schemata, Secondary education, Chemical kinetics

BACKGROUND, FRAMEWORK AND PURPOSE

This paper is part of a broader research that studies the impact of a specific teaching proposal about Chemical Kinetics on the learning process. Special attention has been paid to the distinctive functional knowledge of scientific competence (OCDE, 2010).

The contributions of the schemata theory have proven useful to tackle this problem, as they allow to characterize the way in which student discourse is structured from his reasoning and actions. Regarding this, we have considered the definitions of schemata by Rumelhart and Ortony (Rumelhart & Ortony, 1977; Rumelhart & Norman, 1981). From this perspective, reasoning and thinking schemata (Domínguez *et al*., 2003, 2005) are representations of the knowledge acquired and built by students through learning. This knowledge can be activated in order to use or process specific information.

Rationale

To find out which changes take place in student knowledge, it has been considered necessary to initially characterize the sample. This is the goal of the current work and the first hypothesis of the investigation. This way, in the communication of results, the baseline conditions will have already been defined.

To this end, a series of activities have been proposed to the students. The results of this initial set of tests have been examined using: 1) a per item analysis about the justificative reasonings and the action strategies that the students use in their answers and 2) an analysis of the reasoning schemata and action schemata that students activate when explaining, interpreting and predicting the proposed facts, phenomena and situations. Using these schemata the discourse structure of the students have been characterized, from their arguments and actions.

Learn about what students know is not only a requirement of experimental design, but also gives useful information for the design of the teaching proposal, for using this knowledge in the teaching discourse and practicum and the development of proper methodological approaches.

From this point of view, the following research questions have been posed:

How to make explicit the implicit thinking schemata that students have in a certain instant and a certain domain?

How to make the schemata independent of the situation (problem) used to activated them?

Which are the schemata activated before instruction?

To answer these questions, referential knowledge (reasoning and action) schemata have been developed, to allow dimensioning the desirable knowledge from the point of view of school science.

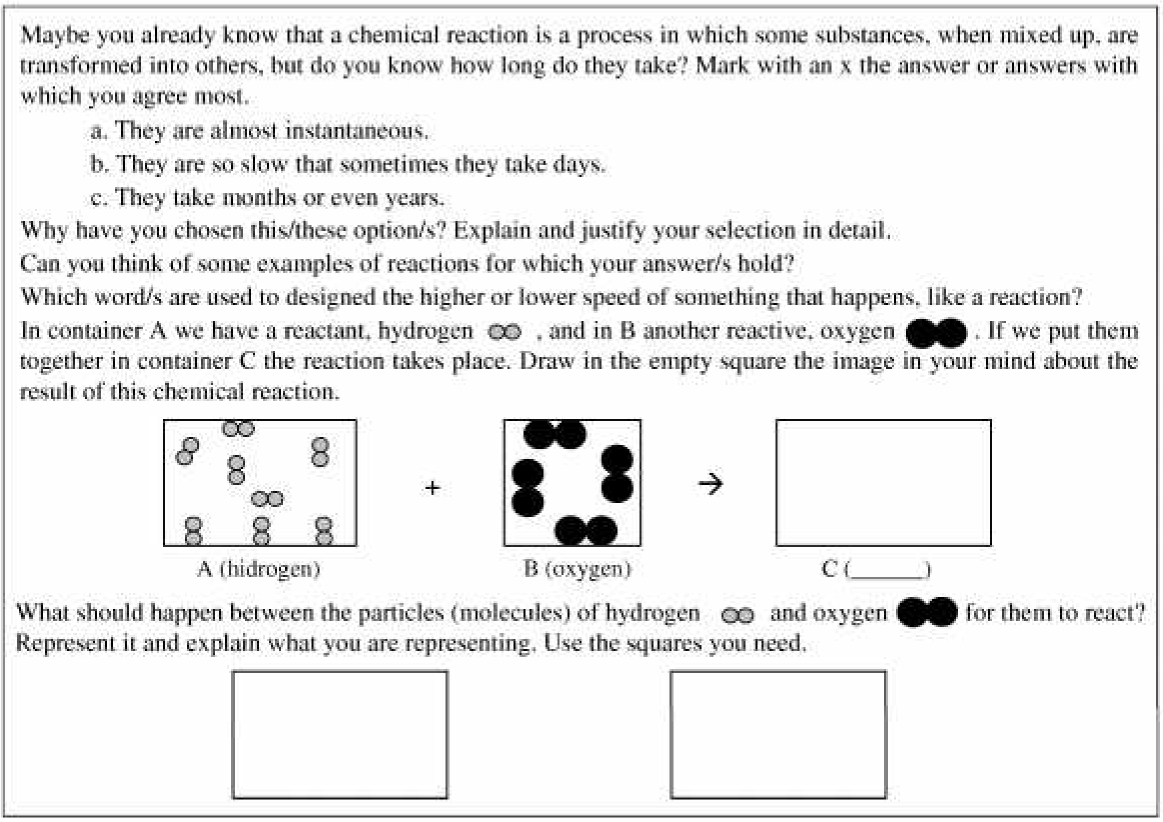
METHODS

Sample

The research is based in a class of fourth year of Compulsory Secondary Education, consisting of a group of five male students and eleven female students aged between fifteen and seventeen. The sample was incidental, where equal representation was not pursued, but a natural and typical situation in education.

Information collection strategy

A total of 8 tests were designed, but because of space reasons only one is shown here (Figure 1).


Maybe you already know that a chemical reaction is a process in which some substances, when mixed up, are transformed into others, but do you know how long do they take? Mark with an x the answer or answers with which you agree most.

a. They are almost instantaneous.
b. They are so slow that sometimes they take days.
c. They take months or even years.

Why have you chosen this/these option/s? Explain and justify your selection in detail.

Can you think of some examples of reactions for which your answer/s hold?

Which word/s are used to designed the higher or lower speed of something that happens, like a reaction?

In container A we have a reactant, hydrogen , and in B another reactive, oxygen . If we put them together in container C the reaction takes place. Draw in the empty square the image in your mind about the result of this chemical reaction.

What should happen between the particles (molecules) of hydrogen and oxygen for them to react? Represent it and explain what you are representing. Use the squares you need.

Figure 1. Initial characterization test

They are practical activities and problematic situations related to the kinetics of reactions. Certain questions are posed that are to be solved with the corresponding jusitificative reasoning. The students' speech and actions have been recorded in audio and video.

Information collection strategy

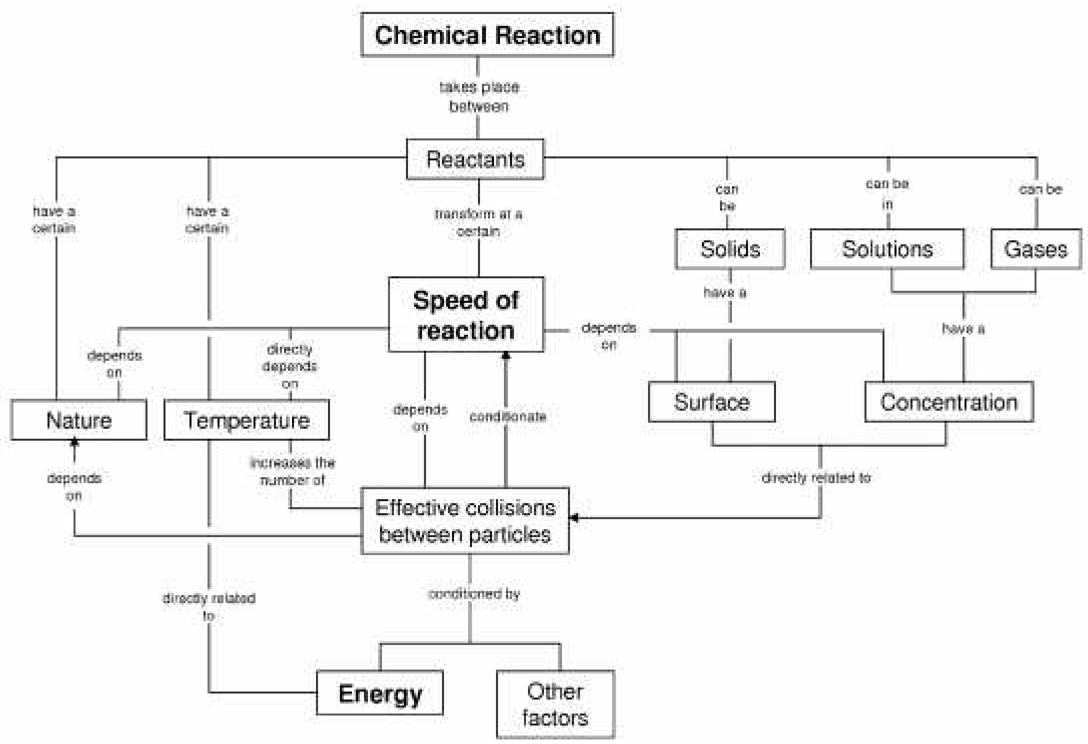
Per-item analysis

A per item analysis has been performed to evaluate the answers of the students to each of the 8 tests. They are exemplified using illustrations and explicative reasonings developed by them. As previously stated, we will only refer to the test described in Figure 1.

Per-scheme Analysis

From the per-item analysis, the explicative discourse developed by the students to interpret chemical reaction kinetics have been fragmented by building their reasoning schemata *"speed of reaction"*.

To avoid researcher bias in the interpretation of the student knowledge (Kesidou & Duit, 1993) the referential scheme desirable from school science has been built (Scheme 1). It will also allow us to graphically represent the reasoning schemata of the subject students.



Scheme 1. School science referential scheme

The structure of relations by which the four factors that modify the speed of reaction (nature of reactants, temperature, surface, concentration) are identified is made explicit in this scheme. Also, the relations between these factors and the interpretative model based in collision theory are also represented in the scheme.

The reasoning scheme is composed of three subschemata: **chemical reaction, speed of reaction** and **energy**, together with a variable, *effective collisions between particles*.

The macroscopic aspects appear on the top of the scheme: *reactants* have certain properties (*nature, temperature, surface* and *concentration*) on which speed of reaction depends.

The explanation of the effect of these factors appears at the bottom of the scheme, depending on the *effective collisions* between particles and the influence of **energy**.

RESULTS

Per-item analysis

In the argumentative discourse built by the students we have found two kinds of reasoning. Note that their answers have been translated from Galician, the official language of Galicia (Spain):

A group (students 3, 5, 7, 8, 13, 15) says that speed of reaction depends on reactants, as stated by student 13:

> *"I think it depends on the substances that you mix. For example, it is not the same to mix water with alcohol (they mix quickly) than to mix water with oil (that do not mix)" (student 13)*

Student 3 uses an everyday life example that makes her doubt of her opinion.

> *"I think they are instantaneous, as I do not think it has to take so long to make a reaction, but if we look at the reaction between oxygen and iron we'll se that they are not so spontaneous" (student 3)*

Wrt. the second group (1, 2, 4, 6, 9, 10, 11, 12, 14, 16), of students who think that reactions are instantaneous, most students identify reactions with mixings. Some solutions are in fact chemical reactions, but not others. Student 16 justifies his answer using his lab experience. Probably this explains the extended opinion in the class of matching reactions with mixings.

> *"... when we do mixings in the lab, reactions take place almost instantly" (student 16)*

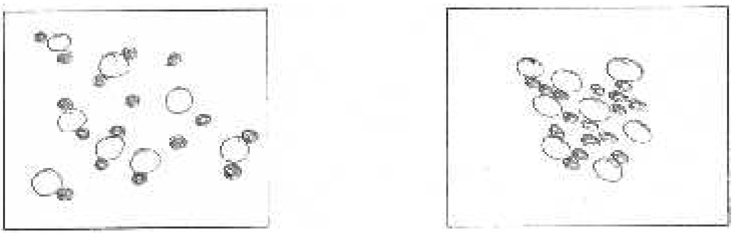
Student 9 is the only one that mentions the term "speed", but she belongs to the group of students that thinks that reactions take place almost instantly. She bases her opinion in combustion examples.

> *"I base in the example of a burning paper. Combustion is instantaneous" (student 9).*

The goal of this work goes beyond this, and we ask ourselves if students will be able to translate this notion to an atomic-molecular explanation. Almost all students make explicit the unions between particles, as can be observed in the following example:

> *"For a reaction between two components to occur, these must mix and touch to achieve the reaction" (alumno 10).*

In the drawing of this student it is observed that, after organizing the atoms in the new molecule, she describes their union when they form the compound.



Student 11 is the only one that searches for a relation between speed of reaction and temperature, saying that it inverse, justifying this by the facility with which particles get together.

> *"There must be a temperature decrease for particles to get near" (student 11).*

This argumentation is probably influenced by precedent instruction, although his prior knowledge is still far from the collisions with which we pretend they justify the influence of the different factors on speed of reaction.

Per-scheme analysis

From the per-item analysis and comparing with the reference scheme (Scheme 1), the relations present in the student discourse through all the 8 tests of the initial characterization have been extracted. This has allowed us to build the reasoning schemata *speed of reaction* of the students, independently of each test, and order them in levels and sublevels.

A total of 5 levels and 8 sublevels *i,o* of the initial characterization of the sample have been established, for the 16 students in the sample under study (Table 1).

These levels indicate the existance of significative differences in the reasoning structures that the students activate. The sublevels indicate the existance of individuals or groups with very similar reasoning schemata.

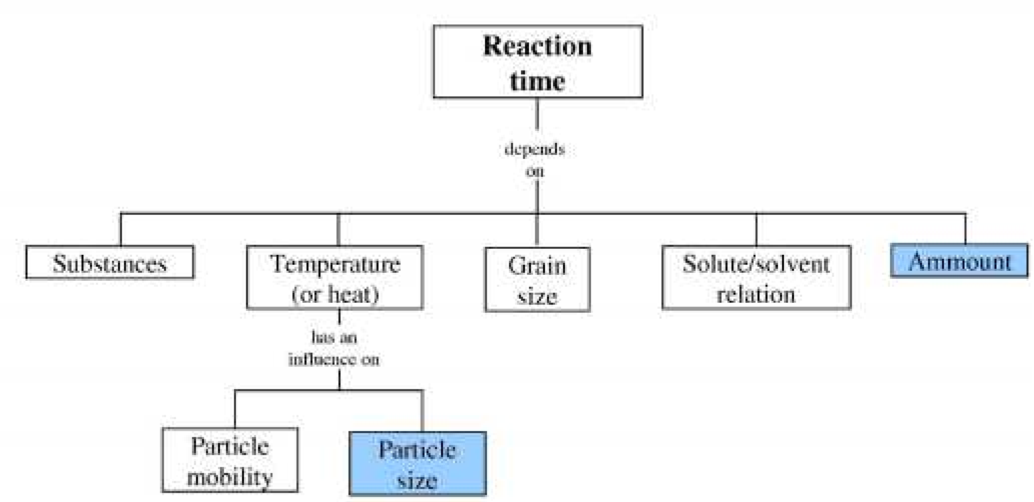
From Table 1, some consequences for the elaboration of the didactic proposal can be inferred: the majority of students do not consider the four factors that modify speed of reaction. Nonetheless, with the help of the test statements, some do feel their influence. Together with these factors, all students propose either others (specially the ammount of reactant or solvent) or they establish an inverse relation between speed of reaction and temperature or concentration.

Levels	*i5*		*i4a*			*i4b*		*i3a*	*i3b*		*i3c*	*i2a*	*i2b*	*i2c*		*i1*
Students	3	5	1	4	11	7	15	8	9	10	14	13	12	6	16	2
Fundamental relations																
Time depends on substances	x	x				x	x	x				x				
Time depends on temperature	x	x	x	x	x	x	x		x	x	x		x			
Time depends on grain size	x	x	x	x	x			x	x	x				x	x	
Time depends on solute/solvent relation	x	x	x	x	x	x	x				x					
Relations far from school science																
Time depends on other factors	x			x		x	x		x	x	x		x			
Time depends on quantity	x	x	x	x	x		x			x				x	x	
Time inversely depends on temperature					x					x						
Time inversely depends on concentration								x	x	x		x			x	x
Temperature influences particle mobility.	x	x								x			x		x	
Temperature influences particle proximity.			x	x	x	x	x	x	x	x	x	x		x		
Time influences particle size.		x														x

Table 1. Reasoning schemata *Speed of reaction*: relations and order levels

None of the students build a discourse that explains, following the atomic-molecular model, the influence of these magnitudes.

From Table 1 and comparing with the reference scheme (Scheme 1) the reasoning schemata of each student can be graphically represented. This allows for an easier comparative analysis between them. Scheme 2, corresponding to student 3 (Table 1-level i5) shows what we intend to say.



Scheme 2. Student 3's reasoning scheme

In this level we include the reasoning scheme that is nearer to the point of view of school science. The dominant scheme ***reaction time***, and variables *substances, temperature, grain size* and *solute/solvent relation* have been activated. It was decided not to call the dominant scheme *speed of reaction* because only student 9 uses this expression before it appears in the test statements of the initial characterization. For the same reason the terms nature, surface and concentration are not used, they have been substituted by substances, grain size and solute/solvent relation. Together with these variables present in the referencial scheme appear other alternative factors relevant for the reaction time (represented with a gray weave).

CONCLUSIONS AND IMPLICATIONS

The current analysis offers valuable information on how to focus teaching.

It can be concluded that students try to use scientific terms which meaning they do not understand, and this leads them to match reaction with mixing, or to apply to atomic-molecular particles terms belonging to the macroscopic world, such as student 9 (already cited) who says that oxygen atoms must fuse with hydrogen atoms. No terms belonging to chemical kinetics appear, nor terms belonging to collision theory.

The answer of student 3 points out the need of explaining the concept of speed of reaction with examples showing that chemical processes take place neither instantaneously nor with the same speed in all cases. It will be necessary to point out that certain reactions, such as the reaction between hydrogen and oxygen (spontaneous from the point of view of thermodynamics) seem not to take place, and explain this from the perspective of Chemical Kinetics.

Students respond to a model different from the collision model. They identify that it is important for particles to get near to react, but not with a collision or interaction. It could be said that the contact between them does not take place at random, because of their agitation, but that instead a static model is used, in which particles do not continuously vibrate, but move in the mixing reactives, and thus they meet.

Student answers include relations that are repeated regularly, so they constitute reasoning schemata. They are incipient schemata, *seeds* in Vygotski's (1979) nomenclature, which teachers must use to work in their ZPD (zone of proximal development) and structure the new knowledge.

The students' reasoning schemata are, in most cases, poorly structured, incomplete and based on undesirable knowledge from the point of view of education science. Because of this, they are not very useful reasoning schemata –*speed of reaction*- to interpret that the speed of reaction of a chemical reaction is influenced by factors as *reactive nature*, *temperature*, *solid surface* and *solution concentration*.

Reasoning schemata can be distinguished wrt. the representative referencial of school science (scheme 1) which makes possible to sort those schemes in different levels and sublevels (table 1), allows to quantify the progress of learning and study the statistical significance of the existing differences.

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A HANDS-ON PROJECT TO ADDRESS ANTIBIOTIC RESISTANCE IN HIGH SCHOOL

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Abstract: The widespread of antibiotic resistant bacteria raises major public health concerns. Aggravated by the lack of new antibiotics, the increase of antibiotic resistant bacteria hinders our ability to control infectious diseases. Having in mind the reported link between antibiotic misuse and overuse and increased resistance phenotypes, public health education interventions to promote rational antibiotic consumption are fundamental. This study highlights the outcomes of a hands-on project to address antibiotic resistance at high school levels (ages 15 to 17). The project *Microbiology recipes: antibiotics à la carte,* was designed to promote students' understanding of biological concepts and processes underpinning the notion of antibiotic resistance, such as bacteria adaptability and the antibiotics' specificity and modes of action. Combining wet and dry lab activities with group discussions, the project is structured to engage the participants in routine microbiology procedures. The effectiveness of this project was assessed through a pre-/post design approach involving 25 high school students (aged 15 and 16). The results provide qualitative and quantitative evidence of students' increased awareness of the perils of antibiotic resistance and of the importance of responsible behaviours. The implications of these findings for science education are discussed.

Keywords: Antibiotics, hands-on activities, health education, high school.

INTRODUCTION

The widespread of antibiotic resistant bacteria raises major public health concerns. Aggravated by the lack of new antibiotics, the increase of antibiotic resistant bacteria hinders our ability to control infectious diseases. In this context, the public's individual choices concerning antibiotics are of paramount importance, particularly considering the reported link between antibiotic misuse and overuse and increased resistance (van de Sande-Bruinsma et al., 2008). Therefore, it is fundamental to promote prudent antibiotic use. Accordingly, several health education initiatives and resources have been developed, as for instance the ones made available by the Centers for Disease Control and Prevention (http://www.cdc.gov/drugresistance/campaigns.html). Nevertheless, not only has the effectiveness of these programmes and materials been seldom validated, but most importantly, studies have evidenced that the general public continues to engage in misinformed antibiotic consumption (Grigoryan et al., 2007). The problem is particularly pervasive amongst the younger populations (Buke et al., 2005).

Imbued by the need to diversify and consolidate interventions to promote rational antibiotic use, this study focuses on the outcomes of a weeklong hands-on project to address antibiotic biosynthesis and resistance at high school levels (ages 15 to 17 years). The rational for this study was based on the following assumptions: firstly, that understanding the concept of antibiotic resistance is required for judicious antibiotic use; and secondly, that this understanding is not straightforward given the abstractness of the knowledge underlying the notions of bacteria and antibiotics, and preconceived ideas surrounding these concepts (Davey et al., 2002; Milandri, 2004). Building on these elements, the project *Microbiology recipes: antibiotics à la carte*, aims to engage the participants in practical activities designed to boost their interest and enhance their understanding about the concept of bacteria, antibiotics, and antibiotic resistance.

RESEARCH DESIGN AND METHODOLOGY

The project was implemented as part of University of Porto's Junior University (http://universidadejunior.up.pt/index.php/paginas/english/home), a program aimed at promoting S&T (Science & Technology) education amongst elementary and high school students (aged 11 to 17), through the development of research-based Summer projects designed by university lecturers and executed by undergraduate and graduate students. *Microbiology Recipes: antibiotics à la carte* was developed as an extension of Fonseca et al. (2011)'s activity about the antibiotic effects of phytoactive compounds, aiming to assess its educational outcomes in an informal context. This was a one-week long project, integrating wet lab (e.g. microscopy, extraction and testing of plant-derived antimicrobials) and dry lab (e.g. bioinformatics, discussions and analysis of scientific papers) activities that took place every day from 9.00 am to approximately 5.30 pm. The modules covered various scientific notions and concepts including those of: bacteria, such as reproduction and growth; antibiotics, for instance production and alternative drugs; and antibiotic resistance addressing causes, consequences, and dissemination of antibiotic resistance genes. The topics and procedures are aligned aiming to: improve the participants' knowledge and understanding about the contents address; promote positive attitudes and beliefs about antibiotic use; enhance awareness towards potential implications of antibiotic misuse/overuse for public health; and increase interest about this issue.

From June 28 to July 9, 2010, 23 grade 10 (n=19, 12 females) and 11 (n=4, 3 females) science students (aged 15 and 16) participated in this project. Following a pre-/post design, qualitative and quantitative data were collected through direct observations, analysis of participants' reports and questionnaire analyses (open and closed questions, Tables 1 and 2). This study focuses on the outcomes of the questionnaire analyses. Data were recorded, codified and categorized. Content analysis of the open questions in both questionnaires was performed according to the guidelines available in Krippendorff (2004) and Weber (1990). The correct and incorrect notions provided by the participants in each question were quantified, and their pre-/post-test variations measured. Using SPSS v.19.0, descriptive and inferential statistical analyses (one sample t-tests, McNemar test and Wilcoxon signed ranks test) were performed to compare the participants' responses.

RESULTS AND DISCUSSION

Understanding the concepts of bacteria, antibiotics, and antibiotic resistance

Concerning the project's learning outcomes (Table 1) positive impacts on the participants' understanding of the concept of bacteria, antibiotics and antibiotic resistance were identified. The participants developed a more elaborated notion of bacteria, as detailed below. There was an increase in the number of correct notions incorporated in the participants' responses, as well as a decrease in the number of incorrect notions (Table 1). However, these pre-/post-test differences were not statistically significant, which is not surprising given the knowledge expectably developed by these students, who had just finished the 10th and 11th grades. In Portugal, the 10th and 11th grade Biology and Geology programmes comprise contents pertaining, respectively, to *cell structure* and *uni-/multicellularity* (Direcção-Geral de Inovação e de Desenvolvimento Curricular [DGIDC], 2001), and *taxonomy and classification systems* (DGIDC, 2003). Therefore, the participants had already been acquainted with the notion that bacteria are *unicellular* ($n_{\text{pre-test}}$=10 vs. $n_{\text{post-test}}$=15, p=0.23), *prokaryotic* ($n_{\text{pre-test}}$=14 vs. $n_{\text{post-test}}$=17, p=0.73) *microorganisms* ($n_{\text{pre-test}}$=10 vs. $n_{\text{post-test}}$=6, p=0.23). Contrasting with the previously reported tendency for bacteria to be associated with illness (Milandri, 2004), the participants were already aware that bacteria can be both beneficial and harmful for humans (Table 1). However, by the end of the project, the participants were able to provide more correct examples of both types of bacteria (Table 1). For instance, in the post-test there were more participants mentioning the positive roles played by the human microbiota ($n_{\text{pre-test}}$=4 vs. $n_{\text{post-test}}$=13, p=0.01). In addition, whereas in the pre-test most of them referred to disease causing bacteria in general to exemplify the negative impact of these microorganisms (n=11), in the post-test they were able to discriminate different types of potentially pathogenic bacteria (e.g. *Bacillus cereus*, n=6; *Ureaplasma urealyticum*, n=2) and bacterial diseases/illnesses (e.g. foodborne illness, n=3; tuberculosis, n=1).

Having a general idea about the phases of bacteria's growth cycle is useful to understand the importance of using antibiotics as prescribed, especially in what concerns the need to finish the course of the treatment (Davey et al., 2002). Nevertheless, the notion of bacterial growth is not always straightforward, namely because it refers to increases in cell number, instead of cell size, as traditionally envisioned by most people (Srivastava & Srivastava, 2003). In this study, the participants' conceptualization of bacterial growth was significantly improved. While prior to their participation, 15 participants did not convey a single idea about this issue, by the end of the project, 24 were able to provide at least one correct notion in this regard (Table 1). The number of participants reporting notions of *bacterial death* and *growth* increased from three and seven in the pre-test to, respectively, 24 and 22 in the post-test (p<0.01). In fact, whereas in the pre-test none of the participants referred specifically to bacteria's growth rate, in the post-test, 22 emphasized the microorganisms' exponential growth. Furthermore, 16 participants were able to identify the four growth phases comprised in bacteria's growth cycle, while none of them did so in the pre-test (p=0.00).

There were significant increases both in the number of students able to define antibiotics correctly, and in the amount of correct notions included in their answers (Table 1). For instance, the notion that some antibiotics affect growth and others kill bacteria directly was mentioned by 16 of the participants in the post-test, and five actually referred to antibiotic's modes of action. This knowledge is essential to increase awareness about the specificity and effects of antibiotics, and enable individuals to make informed decisions on antibiotic use. The results further indicate a tendency for a more comprehensive appraisal of the steps involved in antibiotic drug development and production (Table 1). Whereas there were six participants that mentioned drug development stages in the pre-test, in the post-test 15 indicated tasks involved in antibiotic production, including microbiological ($n_{\text{pre-test}}$=5 vs. $n_{\text{post-}}$

$_{\text{test}}=8$, $p=0.25$) and animal testing ($n_{\text{pre-test}}=1$ vs. $n_{\text{post-test}}=6$, $p=0.01$), isolation and extraction of the compound ($n_{\text{pre-test}}=2$ vs $n_{\text{post-test}}=10$, $p=0.02$) and antibiotic formulation, namely making it more stable by adding other substances ($n_{\text{pre-test}}=1$ vs. $n_{\text{post-test}}=9$, $p=0.01$). The acknowledgement of the complexity and time involved in antibiotic drug development, contributes to a deeper appreciation of the constraints posed at counteracting resistance (Alfonso, 2005).

Table 1. Project's learning outcomes, based on the pre-/post-survey analysis.

	Pre-test	**Post-test**	**Statistics**
How do you define bacteria?			
Number of students providing at least one correct notion	$n=22$	$n=25$	$\chi^2(1)=1.33$, $p=0.25$
Mean number of correct notions (e.g. "unicellular prokaryotic organism")	$M=1.96 \pm 1.27$	$M=2.56 \pm 1.26$	$Z=-0.98$, $p=0.33$
Mean number of incorrect notions (e.g. "unicellular prokaryotic organism")	$M=0.20 \pm 0.50$	$M=0.08 \pm 0.28$	$Z=-0.82$, $p=0.41$
Are bacteria beneficial or harmful for humans? Give some illustrative examples.			
Number of students answering that all bacteria are harmful	$n=3$	$n=0$	$\chi^2(1)=1.33$, $p=0.25$
Number of students answering bacteria can be both beneficial and harmful	$n=22$	$n=25$	$\chi^2(1)=1.33$, $p=0.25$
Mean number of correct examples of beneficial bacteria (e.g. "bacteria in yogurts")	$M=0.56 \pm 0.58$	$M=0.96 \pm 1.17$	$Z=-1.70$, $p=0.09$
Mean number of correct examples of harmful bacteria (e.g. "disease causing bacteria")	$M=0.52 \pm 0.51$	$M=1.24 \pm 1.27$	$Z=-2.49$, $p=0.01$
Describe the main phases in bacteria's life cycle.			
Number of students providing at least one correct notion	$n=10$	$n=24$	$\chi^2(1)=12.07$, $p=0.00$
Mean number of correct notions (e.g. "bacteria reproduce asexually")	$M=0.52 \pm 0.71$	$M=3.36 \pm 1.00$	$Z=-4.26$, $p=0.00$
Number of students answering "I do not know" or no response	$n=15$	$n=1$	$\chi^2(1)=12.07$, $p=0.00$
How do you define antibiotic?			
Number of students providing at least one correct notion	$n=7$	$n=20$	$\chi^2(1)=9.60$, $p=0.00$
Mean number of correct notions (e.g. "medicine that kills bacteria")	$M=0.40 \pm 0.71$	$M=2.44 \pm 2.36$	$Z=-3.59$, $p=0.00$
Mean number of incorrect notions (e.g. "medicine that stimulates the production of white blood cells")	$M=0.36 \pm 0.49$	$M=0.00$	$Z=-3.00$, $p=0.00$
Number of students answering "I do not know" or no response	$n=2$	$n=0$	$\chi^2(1)=0.50$, $p=0.50$
Describe how an antibiotic is produced.			
Number of students mentioning at least one correct notion/phase	$n=6$	$n=15$	$\chi^2(1)=7.11$, $p=0.00$
Mean number of correct notions (e.g. "… isolate the compound", "… test the compound on animals")	$M=0.40 \pm 0.91$	$M=2.04 \pm 2.13$	$Z=-2.60$, $p=0.01$
Number of students answering "I do not know" or no response	$n=17$	$n=7$	$\chi^2(1)=8.10$, $p=0.00$
How do you define antibiotic resistance?			
Number of students providing at least one correct notion	$n=11$	$n=21$	$\chi^2(1)=5.79$, $p=0.01$
Mean number of correct notions (e.g. "… the bacteria do not die in the presence of the antibiotic")	$M=0.52 \pm 0.65$	$M=1.24 \pm 0.88$	$Z=-2.60$, $p=0.01$
Mean number of confused notions (e.g. "the bacteria continue to be pathogenic")	$M=0.28 \pm 0.46$	$M=0.20 \pm 0.41$	$Z=-0.63$, $p=0.53$
Number of students answering "I do not know" or no response	$n=4$	$n=0$	$\chi^2(1)=2.25$, $p=0.13$
Do you agree with the statement: The progeny of antibiotic resistant bacteria is also resistant. Justify your answer.			
Number of students answering yes, with reasonable justification (e.g. "… resistance genes can pass along generations")	$n=11$	$n=18$	$\chi^2(1)=5.14$, $p=0.02$
Number of students answering yes, with confusing justification (e.g.".. bacteria are already 'born' that way")	$n=5$	$n=6$	$\chi^2(1)=0.00$, $p=1.00$
Number of students answering "I do not know" or no response	$n=9$	$n=1$	$\chi^2(1)=6.13$, $p=0.01$
Imagine that you have the flu, you are feverish and aching. In this situation, do you think that antibiotic prescription would be a suitable solution? Justify your answer.			
Number of students answering no (justification e.g. "… the flu is caused by a virus"	$n=7$	$n=17$	$\chi^2(1)=4.50$, $p=0.03$
Number of students answering yes (justification e.g. "…the antibiotic would relieve the symptoms"	$n=11$	$n=6$	$\chi^2(1)=1.23$, $p=0.27$
Do you think that bacterial infectious diseases are currently under control? Justify your answer.			
Number of students answering yes (justification e.g. "… because we have antibiotics to treat infections")	$n=14$	$n=4$	$\chi^2(1)=6.75$, $p=0.01$
Number of students answering no (justification e.g. "… bacteria can resist antibiotics")			
Number of students answering that it depends (justification e.g. "… some are, while others are not")	$n=5$ $n=5$	$n=17$ $n=4$	$\chi^2(1)=8.64$, $p=0.00$ $\chi^2(1)=0.00$, $p=1.00$
List measures that can be used to avoid or reduce antibiotic resistance.			
Number of students providing at least one correct notion	$n=9$	$n=22$	$\chi^2(1)=11.08$, $p=0.00$
Mean number of reasonable notions (e.g. "… do not use leftover antibiotics")	$M=0.56 \pm 0.87$	$M=1.72 \pm 0.94$	$Z=-4.16$, $p=0.00$
Mean number of unreasonable notions (e.g. "… use stronger antibiotics")	$M=0.40 \pm 0.50$	$M=0.12 \pm 0.33$	$Z=-2.33$, $p=0.02$
Number of students answering "I do not know" or no response	$n=6$	$n=0$	$\chi^2(1)=4.17$, $p=0.05$

After the project, most of the participants were aware of the meaning of antibiotic resistance (Table 1), which was perceived as a bacterium intrinsic feature transmitted along generations and potentially transferred among different bacteria species. This is interesting, especially given that a common misconception about antibiotic resistance is that it refers to a status of the person itself and not of the bacteria (Davey et al., 2002). The participants were attentive about bacteria's capacity to adapt to the presence of an antibiotic, by developing mechanisms to counteract its effect and allow them to survive ($n_{\text{pre-test}}$=4 vs. $n_{\text{post-test}}$=11, p=0.09). Furthermore, they also admitted that resistance can be transmitted along generations. When asked to comment whether or not the progeny of antibiotic resistant bacteria would also be resistant, most of them indicated that this can happen, as the genes involved in antibiotic resistance can be passed from one bacterium to its "daughter-cells" (Table 1). One participant even mentioned in the post-test that this process is designated vertical gene transfer. However, the participants seemed to confuse this notion with horizontal gene transfer. It has been argued that horizontal gene transfer is the most important mechanism in the dissemination of antibiotic resistance, by allowing resistance-associated genes to be interchanged between bacteria that may not be phylogenetically related but are subjected to the same antibiotic-induced selective pressure (Juhas et al., 2009). Taking this into consideration, this notion is emphasized in the project, by encouraging the participants to associate resistance with genetic traits, introducing them to the notion of plasmid, and asking them to mobilize this knowledge in thinking of ways in which bacteria can transmit resistance. The fact that this was not reflected in the participants' questionnaire responses indicates the need to revise the instructional design in future editions of the project.

Another common misconception about bacteria and antibiotics pertains to antibiotic use for flu treatment. This notion is known to be related with the belief that bacteria and viruses are identical microorganisms (Buke et al., 2005; Grigoryan et al., 2007; McNulty et al., 2007), and also with the profilactic prescription of antibiotics by the physicians to avoid latent and concomitant bacterial infections (Abbo et al., 2011).Throughout the week, the participants' opinion in this regard shifted from the belief that antibiotics are a suitable solution to treat flu ($n_{\text{pre-test}}$=11 vs $n_{\text{post-test}}$=6, p=0.27), to the perception that this is not a reasonable option ($n_{\text{pre-test}}$=7 vs. $n_{\text{post-test}}$=17, p=0.03). Some of them mentioned specifically that the flu is caused by a virus ($n_{\text{pre-test}}$=1 vs. $n_{\text{post-test}}$=5, p=0.22), and were concerned that incorrect antibiotic use in this regard may foster antibiotic resistance ($n_{\text{pre-test}}$=0 vs. $n_{\text{post-test}}$=10, p=0.00). The fact that the association between improper antibiotic administration and resistance was established by the participants themselves, is quite promising, considering that the use of these drugs for the treatment of colds and flu remains a common misinformed behaviour (Buke et al., 2005).

Beliefs about antibiotic use and antibiotic resistance

The data collected also point towards relevant changes in the participants' beliefs about infectious disease control and an increased consciousness of the urgency and type of measures to counteract antibiotic resistance. When asked if they thought that bacterial infectious diseases are currently under control, the participants' opinion changed from the belief that these are indeed contained (Table 1), mostly due to the existence of antibiotics and disinfectants ($n_{\text{pre-test}}$=13 vs. $n_{\text{post-test}}$=1, p=0.01), to the perception that emerging and re-emerging bacterial infection outbreaks are a major public health issue (Table 1), due to the occurrence of antibiotic resistance ($n_{\text{pre-test}}$=3 vs. $n_{\text{post-test}}$=18, p=0.00 and the difficulties in producing new antibiotics ($n_{\text{pre-test}}$=1 vs. $n_{\text{post-test}}$=5, p=0.13). The identification of this turning point in the warfare against infectious diseases, leads to an increased consciousness about the challenges presented by antibiotic resistance. This is of paramount importance to stimulate public receptivity towards the need to engage in rational antibiotic use (Alfonso, 2005; Davey et al., 2002; Grigoryan et al., 2007). In addition to this increased awareness about the impact of antibiotic resistance, there were also meaningful changes in the participants' beliefs about the personal endeavours that must be made to address this issue. This is particularly relevant considering the importance to foster self-responsibility and to increase the awareness for actions that can be explored to address resistance (Davey et al., 2002). Interestingly, prior to their participation, only nine students suggested that the effects of antibiotic resistance could be mitigated by decreasing antibiotic use and respecting usage instructions. Seven students actually thought that developing new drugs or using different antibiotics were the best or probably the only available solutions. Conversely, following the activities, almost all students (Table 1) highlighted the importance of responsible behaviours, such as using antibiotics only when necessary ($n_{\text{pre-test}}$=5 vs. $n_{\text{post-test}}$=18, p=0.00), and following the physicians' recommendations ($n_{\text{pre-test}}$=2 vs. $n_{\text{post-test}}$=17, p=0.00). The investment in drug development was not dismissed, but it was no longer regarded as the only option, which suggests that the participants are sensible about the importance of individual decisions. Furthermore, while in the beginning of the project there were six participants who did not indicate a single mitigation measure, at the end all of them mentioned at least one. In fact, there was a significant increase in the number of alternatives presented by the participants (Table 1).

Participants' feedback on the project

Overall, the participants enjoyed their participation in the project. As depicted in Table 2, they were very satisfied with the activities, the organization of the contents, and the articulation between techniques and theory presented. They did not find the techniques too difficult, but considered that the success of the tasks proposed required effort. Moreover, they reported that the project contributed to enhance their curiosity and understanding of the issues discussed, and their capacity to critically reflect about those issues (Table 2).

Table 2. Participants' appreciation of the project.

Rate the following aspects on a 1 (Very low) to 5 scale (Very high)	
Difficulty of the contents (M=3.12, SD=0.67, t(24)=0.90, p=0.38)	Contribution to understand the issues discussed (M=4.56, SD=0.65, t(24)=11.99, p=0.00)
Interest of the contents (M=4.44, SD=0.51, t(24)=14.21, p=0.00)	Contribution to critically reflect about the issues discussed (M=4.44, SD=0.58, t(24)=12.35, p=0.00)
Organization and structuring of the contents (M=4.29, SD=0.81, t(24)=7.85, p=0.00)	Contribution to enhance the curiosity about the issues discussed (M=4.56, SD=0.77, t(24)=10.16, p=0.00)
Difficulty of the techniques (M=2.96, SD=0.90, t(24)=-0.23, p=0.82)	Overall satisfaction about the project (M=4.24, SD=0.72, t(24)=8.57, p=0.00)
Articulation between content and techniques (M=4.40, SD=0.76, t(24)=9.17, p=0.00)	
Suitability of materials used (M=4.44, SD=0.82, t(24)=8.77, p=0.00)	
Effort required (M=3.36, SD=0.81, t(24)=2.22, p=0.04)	
Indicate the…	
… most positive aspects (open question)	… less positive aspects (open question
"… learn more about this topic…" (n=12)	"… the theory…" (n=5)
"… improve my laboratory skills… " (n=6), …	"… waiting for the results…" (n=3), …
Make any comments or suggestions you consider necessary (open question)	
"I really enjoyed this project. It was very useful and fun", "I think that activities should continue", …	
Evaluation of the project (1-Mediocre to 5- Excellent) (M=4.36, SD=0.87, t(24)=11.96, p=0.00)	

The participants were particularly pleased about the chance to learn more about the topic and improve their laboratory skills (Table 2). In contrast, the amount of theory presented was pointed out as the major negative aspect of the project (n=5, Table 2). In this project, a major concern is that the theory is aligned with practice and presented it in an appealing way, namely by prompting group-discussions. Even so, it is possible that these participants were expecting a less serious, more entertaining scenario, since they were in the summer holidays. University of Porto's Junior University can be considered an educational leisure context, in the sense that it seeks to promote learning and education in a relaxed, engaging environment.

Therefore, as argued in research focusing on these contexts, some visitors may be more motivated by the expected social experiences than the learning opportunities (Packer & Ballantyn, 2004).

CONCLUSIONS AND IMPLICATIONS

This study evidences the efficiency of a hands-on project to promote informed decision making about antibiotics, by indicating the possibility to interfere with high school students' perceptions and behavioural intentions regarding antibiotic use. The data gathered demonstrate that the participants became more aware of the perils of antibiotic resistance and of the importance of individual choices in this context. The participants' feedback also revealed that they value being given information about these topics through active learning strategies based on practical work. However, this was a small scale study involving high school science students. Therefore, in spite of the statistically significant results obtained, it would be useful to extend this research to populations from different age groups and instructional levels, with diverse curricular backgrounds. The project's modules can be implemented in school settings, by recombining the activities. Moreover, the materials and equipment required are affordable and easily available, and the techniques involved in the procedures are relatively straightforward. The formal implementation of this project would strengthen the evidence of its effectiveness and assist in overcoming biases introduced by sampling students who actively enrol in these activities (Lohr, 2009). Accordingly, from January to July 2011, two of the modules included in the project ("*Natural antibiotics: garlic's antibiotic properties*" and "*A bioinformatic approach to the evolution of antibiotic resistance*") were implemented in seven 12th grade biology classes (4 experimental and 3 control groups) from four secondary schools in Porto. Furthermore, similar initiatives will continue to be implemented in informal contexts, including Porto's Junior University's future editions. Particular attention will be paid to the activities' impact on the participants' awareness about the personal and societal implications of antibiotic use and resistance.

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AN ANTHROPOLOGICAL APPROACH TO ANALYSE A CHEMICAL KNOWLEDGE DURING EXPERIMENTAL DESIGN

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Abstract: In the context of experimental design, students have to write the procedure of an experiment. For this purpose they need to reuse and adapt existing procedures. We studied the procedures produced by students to answer a chemical problem of titration by spectrophotometry. We analysed the content of the written procedures with the Anthropological Theory of the Didactic. This facilitated the analysis of the strategies used by the students, and specifically when the procedure is not satisfactory. To be successful, it is necessary for students to understand the knowledge underlying an experimental task, *i.e*. to relate the technological level to the technical level. We illustrate this with examples.

Keywords: Anthropological Theory of Didactics, Labwork, Experimental design, Chemistry

1) Background, Framework, and Purpose

Experimental design

The experimental design is considered in the context of the broader activity of the experimental process: a subject has to solve a scientific problem through experimentation. During this process, students have to design an experiment to answer the scientific problem. Different studies emphasize the importance of designing an experiment in a learning context. Neber and Anton (2008) observe higher-order cognitive activities (thinking) of students facing such a task. Arce and Betancourt (1997) find that students show better understanding of concepts related to the experiments they designed themselves.

The Anthropological Theory of Didactics, ATD

The Anthropological Theory of the Didactic (ATD) puts forward a model of mathematical activity (especially including school mathematical activity) in terms of praxeologies (Chevallard, 1999; Rodriguez, Bosch, & Gascon, 2007). Even if it was first described in the domain of mathematics, this theory can be applied in other contexts. We will use it to analyse the chemical knowledge during an activity of experimental design in Chemistry.

The general epistemological model provided by the ATD proposes a description of mathematical knowledge in terms of mathematical praxeologies whose main components are types of tasks (or problems), techniques, technologies and theories. The most elementary mathematical praxeologies consist of a practical block or “know-how” (the praxis) integrating types of problems and techniques used to solve them, along with a theoretical block or “knowledge” (the logos) integrating both the technological and the theoretical discourse used to describe, explain and justify the practical block. Thus any “piece of mathematical knowledge” should be described through the statement of what kind of mathematical problems and techniques are involved and what kind of description and justification is given to this “way of doing”.

The objective of this study is to understand what knowledge (logos) the students use when they design an experiment in analytical chemistry.

2) Rationale

This study is part of a larger one that aims at defining the key features of environments devoted to the scaffolding of learners engaged in experimental design (d'Ham, Girault, & Mandran, 2009). The software, copex-chimie (see Fig. 1) used during the current study, is a web-application (http://copex-chimie.imag.fr/) in which the learners have to determine the concentration of the red dye in a grenadine syrup by spectrophotometric titration (d'Ham, de Vries, Girault, & Marzin, 2004). To attain this goal, students must specify an experimental procedure that will be simulated by the application. An artificial tutor is accessible on demand to the learner. This artificial tutor evaluates the procedure, step by step, following a constraint-based system, and it points out the errors to the learner.

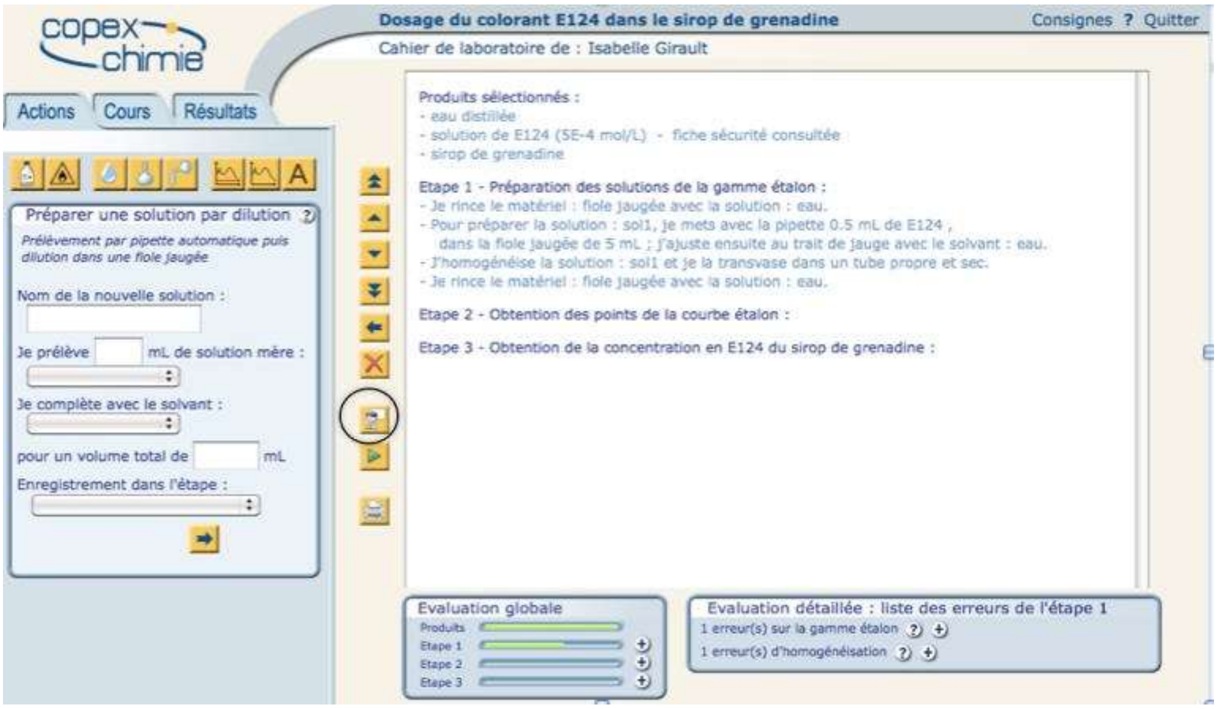

Figure 1: Interface of copex-chimie. The automatic tutor has been requested (see circle) and the bottom right part shows the evaluation given by the tutor.

This chemistry labwork ("determine the concentration of a substance in a solution") refers to design problems (Apedoe & Ford, 2010) where the problem is already given to students and there is no need to formulate hypothesis. The students have to concentrate on the design of the experiment and the analysis of the data to conclude (they do not have to perform the experiment since they obtain their data by simulation, according to the procedure they have described). The general organisation of the procedure is imposed on the students by the structure of the environment, however they have to adapt to and instantiate it. This means that they have to define the low-level tasks of their procedure.

If we use the ATD model to describe the tasks of this experiment, here is an example of praxeology (see Fig. 2). A type of task is "choose a solution to wash the material". In the context of this labwork, an appropriate technique to solve this type of task is to wash the glassware (*e.g.* volumetric flask) with the solvent if it is used to prepare a solution by dilution (or dissolution). The technology that justifies this task is the knowledge about the concentration. For example, when preparing a diluted solution of the dye E124, if the volumetric flask is washed with the E124 solution, the concentration of the final solution will be higher than expected.

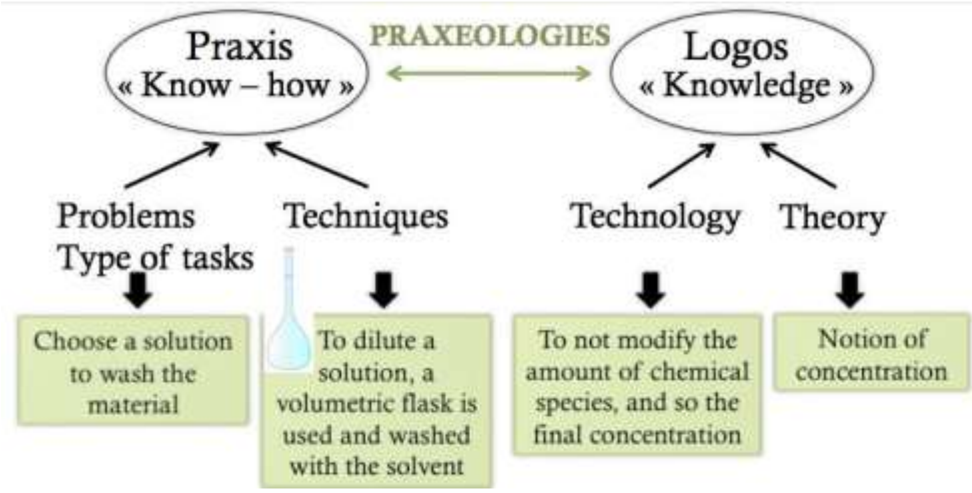

Figure 2: Detailed example of a praxeology corresponding to the task "choose a solution to wash the material (volumetric flask).

The question addressed by this study is the following: Among the praxeologies involved in this labwork, which ones are difficult to handle for the students? The overall goal of this study is the adaptive feedback of copex-chimie.

3) Methods

We first described the reference praxeologies that are the praxeologies expected from the teacher. Then we analysed the praxeologies used by each student and compared them with the reference ones. When a difference existed (it corresponds to errors in the procedure written by students), we checked if the students used a particular technique based on a personal technology (that could eventually be the consequence of a misconception).

Trials with copex-chimie were performed at the University of Grenoble in January 2010 with 103 first year university students. The students worked alone in a computer room during two hours. The teacher briefly presented the work to be done with copex-chimie and then let the students work independently. Log-files containing the activity of the learners during the session were recorded. From these log-files, indicators were extracted to describe the students' work with copex-chimie. These indicators were based on the tutor's evaluation. For example, the tutor indicated that a student did not wash the glassware with the appropriate solution. To better understand the praxeology of this student, we delved more deeply in the log files to have more information (*e.g.*, it is interesting to know which inappropriate solution was used).

4) Results

We present in the table below part of our results.

Type of task	Appropriate technique in the context of this labwork	Technology (justification of the appropriate technique)	Students who did not use the appropriate technique	Students who used a specific inappropriate technique
			(Number of students / total number of students concerned)	
Choose a solution to wash the material (volumetric flask)	To dilute a solution, wash the volumetric flask with the solvent (water in our case)	To not modify the concentration of the solution to be prepared	23 / 103	9 / 23 (Use of E124)
Choose a solution to wash the material (cuvette)	The cuvette needs to be washed with the solution that will be used as a sample (solution of E124 in our case)	To not modify the concentration of the measured solution	63 / 103	51 / 63 (Use of H_2O)
Choose the concentrations of the calibration curve solutions	Calculate an approximate of the highest concentration that belongs to the linear part of the calibration curve (C<Cmax), by using the given order of magnitude of epsilon. Then prepare solutions that are below Cmax.	Beer-Lambert's law is only applicable in a certain range of concentration	42 / 103	32 / 42 (use of a common technique instead of calculating Cmax)
Choose the standard solution for the calibration curve	Choose the known concentration (E124 dye in our case) of the species to be measured in the "unknown" sample.	This will allow to plot the curve A = f(C)	45 / 103	39 / 45 (use of the grenadine syrup)

When students use an inappropriate technique, it is interesting to understand why they used such a technique. For example, for the type of technique "choose the solution to wash the material", most students use the appropriate technique when it concerns the volumetric flask. However, when the same type of task is used in another context (wash of the cuvette), 51 students (out of 103 students, 50 %) use H_2O instead of a diluted E124 solution. This result tends to show that some students use a technique automatically without understanding the technology behind (the justification of the technique) since in the case of the cuvette, H_2O has an influence on the chemical system.

Another interesting example illustrates the same idea that students tend to use a technique without understanding the conditions of its application. It concerns the type of task "Choose the concentrations of the calibration curve solutions". The only information the teacher told the students before they work by themselves with the computer environment was 'to calculate the concentrations of the solutions of the calibration curve you need to know the range where the concentration and the absorbance are proportional. For this, you need to calculate the maximal concentration that corresponds to this linear part'. The result shows that 32 students (out of 103 students, 31 %) chose concentrations made with the following volumes of standard solution: 1 / 2 / 3 / 4 / 5 mL (or very similar to this). Even with the instruction given by the teacher, they did not feel necessary (or did not know how to do it) and instead chose a regular technique used in the classroom, which consists on making dilutions with volumes from 1 to 5 mL. However the standard solution has such a concentration here that all these dilution have a concentration higher than Cmax.

The last example concerns the choice of the standard solution for the calibration curve. The students should use a solution of E124, which has a known concentration. Instead, 39 students (out of 103 students, 38 %) use the grenadine syrup as a standard solution. Apparently these students did not understand the principle of a calibration curve, that can not be plotted if the concentration of the solution is unknown.

5) Conclusions and Implications

The results show that in some cases the students use a known technique, that is efficient in some contexts but appear to be inappropriate in the current labwork. We believe that if students were more often confronted to experimental design, they would be forced to think about the techniques they use and consequently deal with the technology part. This corroborates the findings of Neber and Anton (2008) that students would show higher-order of cognitive activities.

The analysis of the knowledge with the ATD model allowed us to make a fine-grain diagnostic of the difficulties students encounter and better adapt the appropriate feedback. These feedbacks could be at a technique or technological level, depending on the importance of the task in the learning process.

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DO PHYSICS TEXTBOOKS PROMOTE CONCEPTUAL UNDERSTANDING?

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Abstract: As in many other countries, there is a shift in Germany from input (curricular) oriented to output (standards) oriented science education (Schecker & Parchmann, 2007; Nentwig & Schanze, 2007). Thereby the intended curricula contain less content. As this takes place, other curricular materials—like textbooks—become more important for teaching as teachers use them to develop their implemented curriculum (c.f. Valverde et al., 2002). Van Eijck and Roth (2008) point out that teachers use textbooks to guide them in choosing and structuring topics for teaching; they also follow the depth or broadness of specific content in the textbooks while planning lessons. Due to the increasing importance of curriculum materi- als, we analysed physics textbooks concerning their content coverage and content structure using concept maps. Goal of the presented study is to prove whether physics textbooks pro- mote this development of conceptual understanding or whether they present fragmented knowledge pieces.

One result is that almost 90 % of the terms in the analysed textbooks are used only once or twice throughout the entire textbooks. As we were able to show, the textbooks' content covers huge areas but they are only weakly connected. Based on our results it might be argued that the textbooks do not promote conceptual understanding. They instead concentrate on factual knowledge, and even the important terms—seen from a graph-analytic point of view—are rarely used to connect different content areas. As the textbooks fail to develop a coherent con- tent structure which provides conceptual understanding of physics, one might argue that be- sides competence standards a core curriculum is needed. It would promote concepts that are highly important and lead to a similar knowledge that is usable in many different contexts.

Keywords: textbooks, conceptual learning, curriculum, concept map

BACKGROUND

In the most countries, the composition and structure of taught science knowledge in schools is defined on a political level through a curriculum (Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). However curricula are exactly called, there is a general worldwide trend from content oriented curricula (input orientation) to competence based so-called standards (output orientation) (Nentwig & Schanze, 2007; Kauertz, Neumann, Haertig, in press). The decrease of content described in those *intended* curricula might be one reason why most teachers do not use curricula to organize their teaching (Loewenberg Ball & Cohen, 1996).

Textbooks contain a subject area's entire base of knowledge that should be taught in schools, and they present this knowledge in a structured way, depending on different contexts or edu- cational levels. Additionally the content of the books is aligned with the curricula in most cases as authors of textbooks are required to orient their work to the curricula (Valverde et al.,

2009). Teachers in many countries use textbooks to prepare their lessons, for example to de- cide what content to teach and how to present it (Schmidt, McKnight, & Raizen, 1997); they also follow the depth or broadness of specific content in the textbooks while planning lessons (Van Eijck & Roth, 2008). Textbooks may therefore be seen not only as *potentially imple- mented* curriculum, but *actually implemented* curriculum.

Learning materials—such as textbooks—have the potential to support learning, especially conceptual understanding as the number of learned correct associations according to a specific term is highly correlated with the frequency of this term's occurrence in the stimulus text (Shavelson, 1971). This may be explained from a psychologist point of view as the meaning of a 'concept' arises through associations (Johnson, 1964). So through reading and learning associations between the different 'terms', 'terms' grow into 'concepts'. The associations that are built depend on the learner and the used materials. Therefore it makes sense to take a closer look at textbooks and the content they present and how the content structure is pre- sented.

Content analyses of textbooks are typically based on specific coding units like ‘concepts’ as described by Shavelson (1971), ‘major themes’ or ‘key ideas’ in the sense of Chiappetta, Fillman, and Sethna (1991), or ‘ideas’ as Roseman et al. (2010) have done. These coding units seem to be of a different size: An example of a concept is *‘force’*; for major theme or key idea *‘the knowledge of science’;* and for an idea *‘Plants transfer the energy from light into energy-rich sugar molecules’*. We would like to argue with respect to theories of learning (e.g. Johnson, 1964), that ‘terms’ are the smallest unit that a learner would be confronted with. As textbooks are resources for learning and students have to build cognitive structures to develop conceptual understanding, the books should promote this.

A review on existing studies on textbook content concerning Nature of Science shows that textbooks do not cover all the content they should (Chiappetta, Fillman, and Sethna, 1991). Nehm et al. (2008) examined the usage of specific important terms throughout biology textbooks, and they found even these important terms are strictly bound to specific topics. Other studies have shown that today’s textbooks contain a huge amount of different terms without facilitating the learning of the larger ideas (Budianski, 2001). However there is a lack of studies on the whole content of textbooks using a reliable and valid way of coding the content structure. Within our study, we have developed a reliable and valid method to code the whole content structure from physics textbooks as concept maps, which allows different quantitative analyses of the presented content (Haertig, Neumann, & Fischer, submitted).

METHODOLOGY

This study concentrates on the structure of content presented in physics textbooks. Concept maps are suggested for textbook analyses due to the possibility of analyses using graph theory approaches (Borgatti and Everett, 2005). Moreover, this method makes it possible to analyse the content of whole textbooks, which is needed to determine if and how textbooks foster students’ learning.

Borgatti and Everett (2005) provide an overview of different parameters that can be taken into account for analyses of the terms in maps. Degree centrality equals the number of a term’s incoming and outgoing propositions. Based on Shavelson (1971), this parameter provides information about how well the term may be connected in the mental representation of the learners’ content structure. The length of a path as closeness-like measures is the number of steps that is needed to reach one term from another one, while one step is a proposition that connects two terms. In comparison the betweenness centrality does not start with a specific term. Based on other analyses, how often each term lies on the shortest paths can be counted. Both measurements can be seen as ability to connect other terms (Borgatti and Everett, 2005).

Four books were chosen to be analysed; these books are widely used by schools and representative of the widest variance of physics content based on interviews with the publishers. All of these textbooks include grades seven to ten. A guideline for textbook analysis was used to guarantee a reliable, valid and objective procedure (Haertig, 2011).

RESULTS

Two results from other studies have been reproduced: The number of coded terms per book is very high in this study and most terms have a low coverage throughout the textbooks (Haertig, Neumann, & Fischer, submitted). Within our study we could find, that a typical physics textbook contains between 714 and 890 terms with up to 2413 propositions on about 350 pages. The average number of connections per term is 5.8; the average number of terms per proposition is 2.9. Each page of the textbook contains statistically 2.2 newly mentioned terms and 4.3 propositions. In approximately 15% of the propositions, only one term is mentioned, meaning that there are no connections to other terms.

The degree centrality, which is the parameter with the closest relationship to Shavelson's (1971) work, follows an exponential function. So, there are very few terms with a high degree centrality and many terms with a very low one. This is the same for all four books. Furthermore we were able to find a high correlation between degree centrality in the four different textbooks. All four books have in common that most terms (~90%) have a degree centrality of one, which means they are used within exactly one proposition; meanwhile those with the highest centrality are almost the same in all of the textbooks. In a general sense, the other parameters lead to similar results. The analyses show that many of the terms have low values for betweenness centrality, closeness centrality and for the linkage parameter. Very few terms have high values for all parameters. Table 1 shows the 10 terms with the highest values for each of the four parameters.

Degree	**Closeness**	**Betweenness**	**Linkage-Parameter**
Body	Body	Body	Body
Force	Energy	Energy	Energy
Energy	Electron	Electron	Force
Electron	Force	Voltage	Voltage
Voltage	Voltage	Force	Current (phen.)
Current (quantity)	Current (phen.)	Light	Temperature
Light	Light	Direction	Current (quan.)
Resistance	Time	Current (phen.)	Direction
Current (phenomenon)	Direction	Resistance	Light
Inductor	Material	Material	Electron

Table 1: Terms ordered by centrality and linkage-parameter

Even if the different centrality indices correlate on a high level, they are not completely equal. Therefore, some important terms have different functions for the content structure (c.f. Carley, 1997): Some might be better used to connect different topics since they have lots of propositions with different topics. Other ones might be used to build hierarchical connections in a sense of vertical linkage within the content structure as they can be found on many shortest paths. Within our study we could find a correlation between the different parameters on a mediocre level (.265 < Pearson's r < .535; p < .001).

Additionally we could find that most terms have low coverage within the textbooks. Textbooks typically are ordered into chapters like "mechanic", "electromagnetism", or "optics". Only seven terms are used in all topics: time, earth, body, direction, material, gas, and liquid. In comparison to the table above, body is the only term that has high values there, too. Surprisingly, "energy" or "force" cannot be used to connect the chapters' content.

DISCUSSION

Through the use of concept maps, it is possible to identify scientific terms and propositions as they are likely taught. This provides a deeper understanding of the underlying structure and the relationship of physics terms as foundations of students' knowledge. Teachers and researchers should reflect very deeply on the content presented in the textbooks. As we were able to show, the textbooks' content covers huge areas using hundreds of terms but they are only weakly connected. Hence, lots of terms are used very rarely, and the importance of teaching each topic in detail should be debated. It seems as if a broader view and more interconnections between the different topics would be possible with a smaller total amount of terms. Based on our results it might be argued that the textbooks alone do not promote conceptual understanding. They instead concentrate on factual knowledge, and even the important terms—seen from a graph-analytic point of view—are rarely used to connect different content areas. On the one hand, it is encouraging, that 'concepts' like "energy" or "force" get high values in the graph analyses; on the other hand they could be mentioned within all topics—in optics as well as in mechanics—if they are really seen as anchors for a deeper conceptual understanding.

Due to the results a discussion of what comprises a 'concept' could be based on objective data. Comparable to Carley's (1997) work, it should be possible to build groups of terms with common characteristics based on the different centrality measures. Perhaps one of those groups would then be called 'concepts' as they have a high coverage within the textbooks and are able to easily connect different topics. This idea might be connected to what we know from conceptual learning: Learning physics starts with intuitive (naïve) ideas that the students already have based on all-day life experience. This knowledge is highly robust and very fragmented, which leads to problem specific solutions based on surface features (e.g. Hammer, 1996; Chi & Slotta, 1993; Chi, Feltovich, & Glaser, 1981). Besides being taught about the science physics there is no specific reason for students to 'forget' their intuitive ideas. Therefore either from a misconceptions or a p-prims point of view lot of effort has to be spent to deconstruct the misconceptions or refine and integrate the p-prims (c.f. Taber, 2008; Sabella, 1999; diSessa, 2008). This can be seen as learning progression (in sensu Liu & McKeough, 2005), which is as well dependent of general age-dependent abilities as of well organised curricula, well prepared teachers and last but not least well designed curriculum materials.

By taking both into account, learning of conceptual knowledge and our results from the textbook analysis, we would like to state that today's (German physics) textbooks do not support conceptual understanding. Therefore they would have to focus on a core of knowledge which might be based on those terms, which serve as concepts from an expert point of view. For this reason a core curriculum could be a really helpful supplement to the already existing standards from our point of view as it will guide the teachers through developing their own implemented curriculum. Terms and relations for such a core curriculum may be found by applying the concept mapping method presented within this study and deleting those 90 % of terms which are used only once or twice, concentrating on terms that are highly connected and their relations among each other.

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INFORMAL LABORATORIES AND PUPILS' REASONING IN INTERPRETING ELECTROSTATICS INTERACTIONS

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Abstract Research in secondary school shows that it is particularly difficult the interpretation of simple phenomena of electrification and charge transport. The lack in simple charge interaction phenomena analysis appears to be important. We therefore organized activities of experimental exploration to support the building, from primary school level, of the concept of charge and its properties as guided reflection on macroscopic experiences. Informal and ludic approach appears to be useful in spontaneous reasoning analysis. In the context of the hands-on exhibition Games Experiments Ideas (GEI) in Udine and in Crema (MediaExpo 2009) were offered to pupils of 10 primary schools classes Conceptual Laboratories for the Operative Exploration (CLOE) on charge processes for phenomenological explorations in the light of the discussion of interpretative hypothesis. The process of building the interpretive reasoning of the phenomenology is explored and analyzed by means of the recording of small group discussions, interviews and stimuli cards/worksheet. The transition from a spontaneous vision of phenomena to a scientific one is the main focus of the analysis. The analysis of material collected during the activity provides information about students reasoning in interpreting the processes of charging.

Keywords Electrostatics; charge; primary school; reasoning; interpretation.

INTRODUCTION

Background, Framework and Purpose

Electrostatics offers many interesting aspects in developing scientific reasoning and formal thinking. It is the area where the electric nature of matter and some main concepts of electromagnetism (charge, potential and electric field) are built. It offers the opportunity to contextualize some constraints framing the subject content of physics: the principle of conservation (of the charge), the superposition principle, the concept of dynamic equilibrium. From a methodological point of view, electrostatics offers opportunities for exercising logical inference with regard to the conclusions that could be drawn from an analysis of macroscopic states and processes for the construction of reasoning aiming at an interpretation of the microscopic world: from changes observed at the macroscopic level after specific actions, evidence is obtained supporting the existence of the charge as an internal, mobile and twofold property of matter. This process is an example of scientific ways of looking in the study of phenomena and illustrates how science builds its hypothesis. Interest of science education research for electrostatics arises also from the problem that the lack of connection between electrostatics and electrodynamics is the basis of specific learning difficulties in this field (Eylon, 1990). The students' macroscopic description of electric circuits is not linked to the microscopic quantities introduced in electrostatics. Other authors pointed out that previously acquired knowledge in electrostatics is re-used in the context of circuits in an unchanged form, without adapting it to the new context (Benseghir, 1996). Part of the students' reasoning in electrokinetics come from a conceptual basis which includes a more or less intuitive knowledge of electrostatics, using the concept of electrical charge instead of the more abstract concept of potential difference in the analysis of the circuits. The students' focus is on the charges that they ascribe to the ends of the battery. Following these conclusions, specific interest arose for the reasoning in electrostatics. Research on learning difficulties in electrostatics can be divided into two areas. Some studies were carried out about the more formalized aspects of the electric field, Gauss law, electric potential (Törnkvist, 1993; Rainson, 1994; Viennot, 1999; Furio, 1998, Maloney, 2001), focused on high school or university students. Other studies are focused on the basic phenomena helping to build the first electrostatic interpretation: the process of electrification of bodies by friction, contact or induction and charge transfer (Guruswamy, 1997; Furio, 2004; Zubimendi, 2005; Guisasola, 2008). Again the involved students are in high school or university. We conducted inquiries at lower age (GEI) (Michelini, 2007) confirming the assumptions made for older students (Furio, 2004) on the spontaneous use of models already historically emerged during the development of the theory. The results of these studies show that simple phenomena of electrification by friction and induction are interpreted by the students according to four main models: Creationist, Halo-effect, Fluid, Newtonian. After researches on how electrostatics is learned, teaching/learning sequences and strategies are being developed to go beyond learning nodes that lead students to non-scientific conceptions (Guisasola 2008). The persistence, in spite of schooling, of these non scientific models leads us to suggest the anticipation of phenomena exploration and the reasoning analysis for conceptual change process. This to exploit the attention to the phenomena that is part of the natural curiosity of children, and to avoid rooting of the interpretative models of common sense, consolidated and reused in several experiences (Viennot 1999, Michelini 2004). Following empirical studies on teaching/learning paths about basic electrostatic phenomena (Zubimendi 2005, Michelini 2007, Guisasola 2008, Mossenta 2010a and Mossenta 2010b) a proposal was designed, according to a vertical path from primary to secondary school level.

We present a research study carried out in a CLOE (Conceptual Laboratory for the Operative Exploration) context with 114 students of primary and middle school, during open informal activities offered to schools. The research is aimed to study spontaneous reasoning in context of emblematic situations and the reasoning evolution during games proposed for charge processes exploration.

Rationale

The study refers to a module of activities proposed to pupils. All activities are offered in a consistent and comprehensive way as a framework for exploration. The rationale of the intervention module aims to build the concept of charge as property acquired by the objects, after a preparation that makes them be in a state allowing them to interact in different ways by virtue of the property. All ways are based on two types of property, produced by entities necessarily always present inside the objects, that can be activated in different ways and responsible of the electrical interactions. These entities can move in the objects and from one object to another and keep unchanged their total amount. Some steps are stated for developing this interpretation process: from the simple observed interactions to the concept of charge as a state property of prepared objects. Our study aims to inquiry if it is possible to drive pupils to a construction of the interpretative framework through experimental exploration of different ways of electrifying objects, focused on the macroscopic properties of the electrical interactions. The proposed situations involve adhesive strips pulled from the same area, to recognize a property (repulsive effect) acquired from the tape as a result of the pulling; objects as plastic labels and straws rubbed with the same material, to generalize the situation; the same systems, but prepared with different materials, to recognize attraction and repulsion as different ways to interact, characterizing the property of the interacting systems accordingly; systems pulled or rubbed together, for a first introduction of the conservation of the charge.

We studied the extent to which children's reading of experiences involves identifying aspects scientifically relevant, descriptive and interpretative, according to the purposes for which the experiences were proposed. The research questions were therefore as follows:

RQ1: In what terms pupils read the behavior of the observed systems: descriptive or interpretive, according to a vision that considers the whole system or stops at a local view centered on the individual components?

RQ2: Do pupils identify the action that changes the state of systems? And that this will change the way they interact with other systems?

RQ3: Do pupils identify elements of explanation of the systems behavior? What are these elements? What are their features?

The underlying macro problem is the role for the learning of the proposal in its different aspects: cultural, cognitive, conceptual, methodological and operational. We studied the possibility of activating in the children interpretative tools, as reasoning looking to states and processes or closed logic and consistent inferences grounded on the experienced phenomena.

METHODS

In the first part of the proposal, tested in CLOE sessions, stimuli explorative cards are used (Martongelli, 2001; Michelini, 2004) helping to record ideas, and a strategy of Situation-Prevision-Experiment-Analysis, SPEA (Michelini, 2009): the presentation of a situation to the pupils, their justified prevision about its evolution as a result of a specific action, the experience and an analysis of the outcome compared to the prevision, referred to the reasons previously expressed. The activity involved primary school classes (10, fourth and fifth classes) and 1 middle school class: 114 pupils aged 9-11. It was conducted in small group sessions for an hour; the interpretation of experiences of charging by pulling/rubbing was proposed, and children individually filled the cards after the experiences and discussion on them. The analysis of these data allowed to keep track of the processes put in place during that activity. The answers written by the pupils on the worksheets were classified according to categories, related to the purpose of each step; they were defined a-priori from literature and previous activities and re-defined a-posteriori with the aid of the audio-recorded answers in interviews and discussions, to detect the pupils' ideas and the kinds of explanations after each experiment, and the evolution of ideas and explanations during the activity.

RESULTS

Following the first experience, in which two strips of adhesive tape were approached after being pulled from the same place, all pupils identified a change in the state of the system observing the changed behavior of the pulled strips. Asked to specify the observed behavior, pupils gave answers that can be classified in two categories: I) descriptive (71/114 pupils), and II) interpretative ("they repel each other"/ "They do not attract each other"43/114 pupils). The descriptive category (I) refers the movement observed in the strips according to two subcategories: Ia) a single system whose parts changed their respective positions, "the tapes went away one from the other" (58/114 students), Ib) two separate systems that are deformed, "the tape is bent outward (13 pupils of fifth class). After the later experience of rubbing plastic labels and straws, most of this group changed the answer (11 out of 13 pupils) and claimed that the two observed systems went away one from the other: they maintained a descriptive view, but gained a more global perspective during the different explorations. The pupils of the other categories maintained their first way of looking at the phenomena during the different experiences proposed to them.

After observing the system behavior of the two tapes, pupils were required to identify the actions producing the observed behavior: almost all pupils (108/114) described actions related to the observation of system behavior, without being precisely the conditions that produced it: they are sometimes records of observed actions. These are the mechanical actions performed on the tapes (attacking/pulling off the strips) and their approaching after their pulling (bringing tapes one near the other); the action of pulling is identified as the triggering action by 88/114 students. The interaction with the table (attaching) is focused by a few (19) pupils. Almost as many pupils consider only the action making the state visible (approach) and not the action that produces that state (13 pupils out of 54 citing it). Very few (3/114) pupils cite all the actions responsible for the activating of the tapes. In a fifth class, 6/13 pupils use interpretative quantities and a model of supply when asked about the action performed on the tapes: “maybe we gave it the energy" / "we gave electricity with the strong pulling". This change of level is not repeated dealing with the following experiences.

Coherent explanations of what produces the behavior of the tape are given by 75/114 pupils. The interpretations are based on two kinds of elements: a) proper of physics or pseudo-physics (84): force, energy, electricity, B) proper of the context (18): process variables noted, such as materials or the procedure used to change the status of the observed systems. 58 pupils relate the explanation to the action of activation, according to 4 categories of elements of explanation: a1) materials and activation mechanism (10 explanations, 3 involving a mechanism: “it takes something from the material”); a2) energy (taken during the pull, 24); a3) electricity/charge (taken or created or produced during the pull, 23); a4) the action of pulling (1); 26 pupils link the explanation to the observed interaction: 25 pupils attribute the interaction to a force, magnetic for 23 of these (“because there is a magnetic force”), only 1 pupil claims a description; 18 pupils relate the explanation to contingent factors (heating, gravity, the glue). In the fourth classes the explanation (one for each pupil) is mostly based on a interpretative quantity (7 pupils do not respond, 18 use the idea of force), in the fifth classes explanations become complex and the explanations are based on several factors: "the glue that is here, magnetism, a kind of energy, electricity is created in the pulling". The same question proposed after the experiences involving different objects and ways to activate them produces a cue about the coherence of explanations: 10/73 pupils modified their explanations, changing the involved entity (6) or introducing the preparation or the change of state as explanation (4). 5/73 pupils enriched their explanations with a mechanism regarding the same explaining entity; 12/15 students of the same class modified the explanation after experiencing the action of rubbing plastic labels, saying that "there is something inside the label". A final discussion into a group of 11 pupils of 4th and 5th class confirm that pupils recognized the involvement of two objects in every experience; that the observed 2 behaviors of the systems were produced by the action of pulling or rubbing, the condition on the objects to obtain these behaviors, in terms of preparation: “When you do the same thing they repel each other, when you do not do the same thing they repel or attract each other”. After the activity 16 pupils of 5th class and 13 of 4th class were asked to tell to a friend what is happening in 2 situations, proposed by two pictures of adhesive tapes repelling and attracting, and to explain him/her what happened in the tapes to produce these behaviours. 14/29 pupils express an explanation, 7 of them involving charge or energy (“In fig. a) the tapes attract because in one there is a positive charge and in the other negative. In fig. b) they go apart because the charges are both negative”), 6 referring to a preparation linked with the experiences seen (“In fig. a) the tapes approach because they were rubbed together. In fig. b) they go apart because they were pulled off the same material”), 1 referring to contingent and anmistic causes; 3/29 pupils give an interpretation in terms of interaction without elements of causality ("In fig. a) the tapes attract and in fig. b) they repel"); 12/29 pupils only describe the behavior ("In fig. a) the tapes come closer and in fig. b) they go apart"), as a movement of two parts of a system.

CONCLUSIONS AND IMPLICATIONS

The considerable number of pertinent answers to the questions, even in the starting activity, with pulled adhesive strips, suggests that the tasks are well- established for the pupils level. As regards the research questions, we argue that the reading of the behavior of systems shows a rather sharp distinction between the fourth and fifth classes. The fourth classes look substantially in terms of interaction, repulsion between the tapes, while in the fifth classes are limited mostly to describe the observed behavior of distancing. Moreover, in this case emerges a description that seems more attentive to the changed appearance of the single tape, which "leans", than to the relationship between the two tapes as an interacting system. The simplicity of the experiences has facilitated their reading, but not the process analysis. The majority of pupils in this group after examining later experiences noted the distancing one from the other of the interacting systems. This supports the need to propose a lot of experiences, varying conditions, to facilitate the identification of significant elements for the analysis of the phenomenology. The fact that the vast majority of pupils in fourth class of primary school read the experience in terms of interaction indicates that reasoning based on it can be carried out since this level of education; confirming it the majority of pupils in the fourth class still shows the forces when providing an interpretation of the experience. The reasoning in terms of interactions can be carried out from primary school level, with long-term thinking. The vast majority of students identified the pulling as the action that produces the new behavior of the system, but almost half of the students also indicates the approach, which makes visible but does not determine the interaction. Again, as confirmed by subsequent experiences of friction, providing many experiences helps to identify the role of the magnitudes involved. The explanation of the observed behavior is given by a good number of pupils, who resort to physical entities for the interpretation: this is mostly the outcome of considerations that involve multiple entities and mechanisms in which the interpretative magnitude plays an improper role: it is necessary to get used pupils to the strict reading of the macroscopic phenomenology to help them in acquiring awareness in the control of inferences. From data emerge that pupils often modify their previous idea and describe processes in more generalized way, less related to the single system/situation and to contingent aspects. Finally, changing the way of prepare the charged state, they tend to interpret the observed phenomena as result of a process of interaction between two sub-systems or almost they tend to consider all the two sub-system as a whole. Observing the same process in different ways pupils overcome a vision linked to local descriptive/contingent details, looking at the whole system and process as such. This conceptual steps is usually activated by the SPEA cycle. The habit to propose to the learners only one experience (usually regarding induction) is not enough to produce adequate learning outcomes. Observing that the class where in a first time emerged mechanisms of explanation has come to identify the presence of "something" in the systems as an element of explanation, in advance of the planned steps in the path, the search for interpretation by pupils should be encouraged. To get that the identified entities are used in relevant ways, groups of different experiences are needed, which lead to highlight further properties of charge (in particular its mobility), while consolidate and clarify the basic interpretative idea. In this way the interpretation process is facilitated and new meanings are produced.

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SCIENTIFIC KNOWLEDGE AND LEARNING IN BIOLOGY AND GEOLOGY: BETWEEN PHENOMENON AND EVENT

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Abstract: In France, biology and geology are associated in a whole subject matter called Sciences de la Vie et de la Terre (SVT, Earth and Life Sciences). This association is justified by the double dimension of these sciences, as they are both functionalist (they study living systems and Earth functioning, respectively) and historical (they reconstruct the evolutionary history of living beings and the Earth's past) sciences. This double dimension induces didactical problems due to the fact that, on one hand, most of the questions to work on in SVT classes are hybrid (both functionalist and historical), and on the other hand because students use storytelling to solve historical questions. Which references could help to go beyond these difficulties? Our communication aims to build them by situating SVT between phenomena and events sciences. By considering two historical problems (the formation of a mountain range, and the origin of life on Earth), we perform a comparison analysis of the way events and phenomena are mobilized by researchers and students. We show that, due to a lack of experience in biology and geology, students involve "catastrophic" events and thus remain in a common thought. We notice that the French curricula give no clues to teachers to deal with this epistemological issue.

Keywords: biology, geology, event, phenomena, student

INTRODUCTION

In the French curricula, biology and geology are associated in a whole subject matter called *Sciences de la Vie et de la Terre* (SVT, Earth and Life Sciences). This association, which does not exist in all countries, was justified by their double dimension (Mayr, 1982 ; Gould, 1989) : biology and geology are both functionalist (they study living systems and Earth functioning, respectively) and historical (they reconstruct the evolutionary history of living beings and the Earth's past, respectively) sciences.

- For biology, Mayr emphasized that « *there is hardly any structure or function in an organism that can be fully understood unless it is studied against this historical background* » (1982, p. 69) ;
- For geology, Gould said that the trend of considering this science as "soft" or "merely descriptive" as opposed to "hard" and "rigorously experimental" science is because it requires the tools of history for explaining some natural phenomena (the Cretaceous exctinction, for example).

In this communication, we analyse the didactical consequences of this characteristic by considering the theoretical framework of *learning-through-problematization* that strongly links learning to problems'construction and admits that the scientific knowledge not only contains the solutions to these problems but also the reasons that make them necessary (assertoric knowledge vs apodictic knowledge).

RATIONALE

This double dimension leads to didactical issues because, on one hand, the problems to be treated in SVT classes are hybrid (functionalist and historical) and, on the other hand, students tend to make small stories (*storytelling*; Orange Ravachol, 2010).

- The seafloor spreading, for example, can be seen as a functionalist problem (the current functioning of a mid-ocean ridge) but also as a historical problem (reconstruction of an ocean history);
- Most of students reduces the seafloor spreading problem to plates drift stories. For scientists, the plates are in constant renewal; for students, they are as characters that can move away or get closer on the surface of the Earth, while keeping their integrity.

This communication, which takes place within the theoretical framework of *learning-through-problematization* (Fabre & Orange, 1997), tries to define the conditions that would allow to overcome these difficulties, from case studies.
In order to identify the conditions of an understanding and an assimilation by students of the double dimension of the SVT, we need to improve the epistemological structure of these disciplines.

What links biology and geology?

Due to their double dimension, functionalist and historical, biology and geology have a complex connection with time (Orange & Orange, 1995). To reconstruct the past, thus unique, living beings history or Earth history, these subject matters need to invoke contingency and to produce a time not entirely definite, and that provides singular events. Time becomes history by building events (Tintant, 1986).
However, in their functioning, biology and geology also show a tendency to move away from history and thus from historical events:

- When they explain by invariable laws in time and space how the Earth or living beings are functioning, they build a “void” time that gives no place to event.
- When they use the principle of actualism, they bring an historical dimension back to a functionalist dimension, so events are withdrawn in favour of phenomena.

Biology and geology therefore operate in paradoxical ways. To construct a reasoned history of Earth or living beings, they identify past events as current phenomena. By doing so, they appears like they are "killing" history. But it is to eventually better find it, because events become necessary when the projection on the present time is impossible.

What distinguishes geology from biology?

By using the principle of actualism, geology usually succeeds in bringing an historical dimension back to a functionalist dimension, thus changing events into phenomena. On the opposite, historical biology remains marked by the consideration of contingency and events, as it involves the history of mankind, which gives sense to events that appear crucial. We can use as examples some historical problems: the formation of the alpine range, the dinosaur extinction, the origin of life on Earth. Despite all these problems took place at different moments of Earth’s history, and thus have factual characteristics, they are not treated in the same way by the scientific community (Table 1).

Examples of historical problems	Treatment by present scientists.
Formation of the alpine range	- Treated as a phenomenon (an example of the formation of a mountain range), by using an elaborate form of the principle of actualism.
Dinosaur extinction	- Treated as a phenomenon (an example of biological crisis), by using both elementary and elaborate forms of the principle of actualism. - Treated as an event when it allows to explain the rise of Mammals during the Tertiary.
Origin of life	- Succession of events, at least during a part of the process (non robust reactions).

Table 1. Some problems in historical geology and their treatment by present scientists

So we can sum up on the next figure (Figure 1) how complex is the relation between phenomemon and event, both in biology and geology.

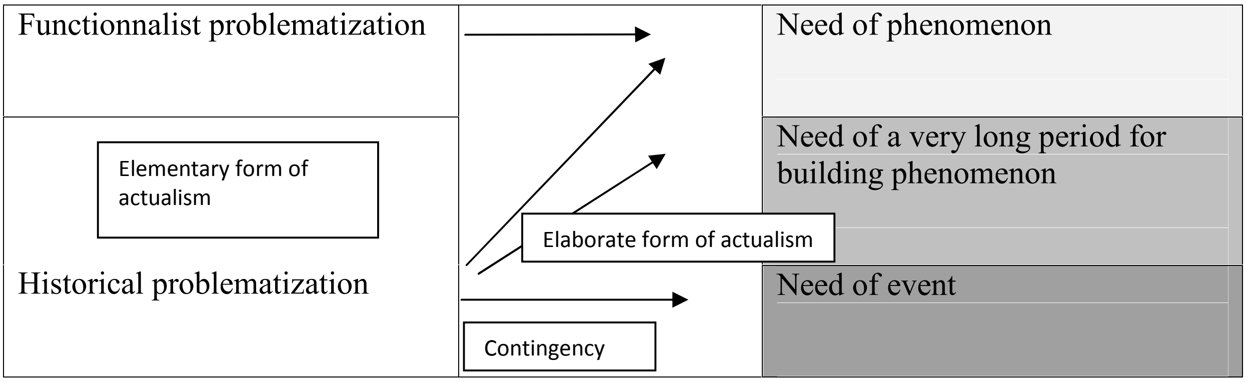

Figure 1. Functionalist and historical problematizations and phenomenon and event construction

Several kind of contingencies are not taken into account by scientists:

- The possibility that Alps could have not existed does not interest them; instead of considering this formation as an event, scientists consider it as a kind of orogenesis.
- On the opposite, the fact that the dinosaur extinction could have not happened is considered, probably because it conditions what happens afterwards, until the apparition of the human species (Stengers, 1997).

Biology and geology thus do not take into account phenomena and events the same way, which allows to anticipate didactical issues.

METHODS

Our studies deal with a comparative analysis of the way events and phenomena are mobilized during the *problematization* of two historical problems (the formation of a mountain range, and the origin of life), by researchers and students. For that, it is based on:
1) an epistemological analysis of the knowledge involved ;
2) interviews with specialized scientists ;

3) the explanatory and argumentative productions of students facing these problems (grades 11-12, 16-18 years-old) during individual works or semi-directive interviews.

From the point of view of using the principle of actualism

Geologists explain the formation of the Alps (figure 2) by using the principle of actualism :

- pillows lavas (“*laves en coussins*”) found in the mountains are pieces of an ancient ocean (analogy with the current ocean expansion)
- the presence of relief is linked to current compressive processes, over a very long period of time.

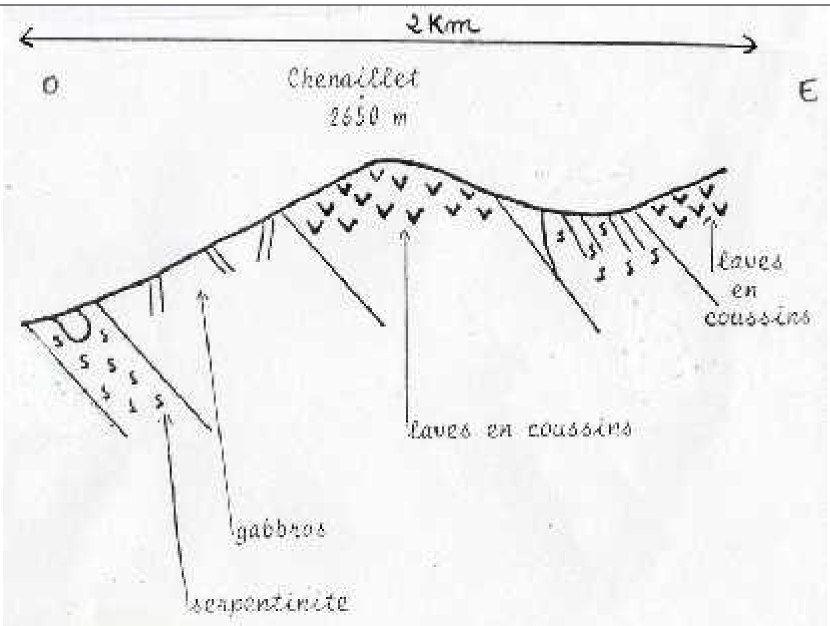

Figure 2. Cross section through the Alps (Mount Chenaillet)

Do students refer to current processes? Do they build the necessity of a long period of time producing the orogenesis ?

From the point of view of a retrospective reconstruction of the event

Geologists explain the origin of life by a succession of events whose occurrence was very uncertain *a priori*. They establish these events with a retrodiction approach (figure 3).

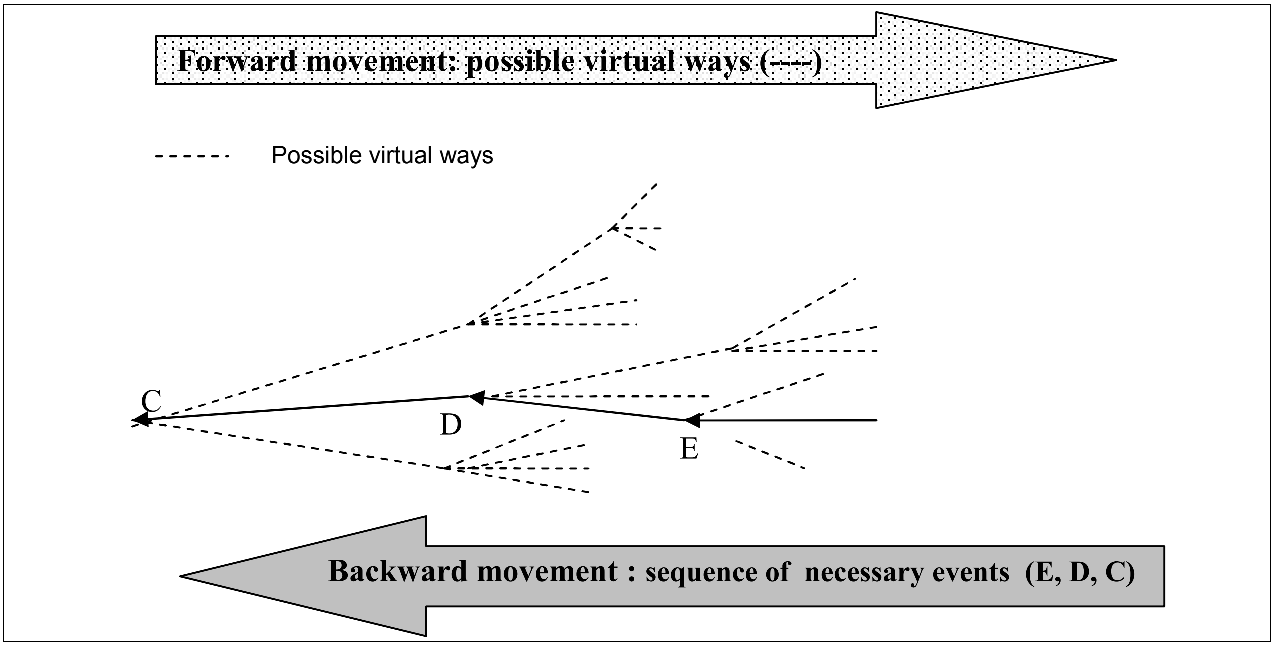

Figure 3. Contingency, virtual possibilities and event needs

The origin of life becomes a necessary event when we consider the history of life backwards. Do students consider the apparition of life on Earth as a common phenomenon or as a singular event in space and time? If they consider it as an event, how do they build it?

RESULTS: STUDENTS FACING EVENTS AND PHENOMENA

In their explanation of the formation of the Alps (figure 2), students situate pillows lavas on a seafloor and they imagine movements explaining their present location. But these movements are not controlled and have no constraints (figure 4). These are *ad hoc* events; everything is possible within time and space. Instead of looking on the orogenesis as a phenomenon and constructing the necessity of a very long period to obtain it, they consider it as a catastrophic event.

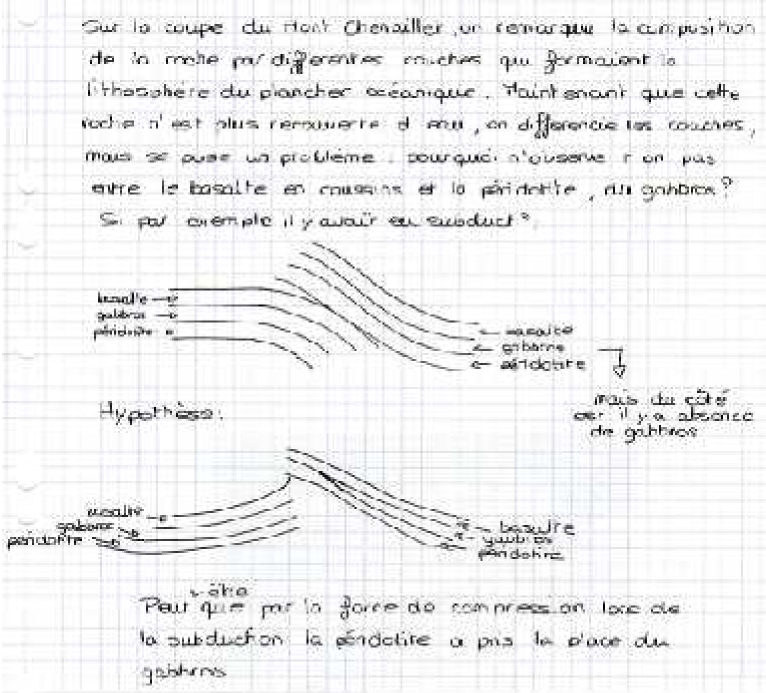

Figure 4. A student's explanation of a part of the Alps (Mount Chenaillet)

Most of students consider the origin of life on Earth as a common event: when condition where favourable (suitable temperature, presence of liquid water), living beings appeared. Some of them imagine the apparition of life by starting from the present time. As scientists, they take the history backwards (example: the sexual reproduction where it is impossible to have children without parents ; obtaining plants from seeds placed in favourable conditions) and have difficulties to construct the necessity of an origin. Students are thus able of reasoning by taking the history backwards or forwards. But by going backwards, they do not find an origin; and by going forwards, they make simple forms that evolve as they wish, without constraints.

CONCLUSIONS AND IMPLICATIONS

The usual reasoning way of students does not lead them to understand the distinction between events and phenomena. Students frequently use events in a short story. This tendency is already used in physics (Viennot, 1996). If they are powerless, it is mainly because they are not able to control their story and to construct the necessity of each event, due to a lack of theoretical and empirical experience in biology and geology. The use of the events by students is thus in a catastrophic or stopgap way. Behind this lack of distinction between event and phenomenon, we show that they miss a fundamental characteristic of historical biology and geology and the essential difference between them.

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ACCEPTANCE AND UNDERSTANDING OF EVOLUTION THEORY: A COMPARATIVE STUDY OF GREEK AND SERBIAN TEACHERS

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Abstract: In this paper a comparison between Greek and Serbian teachers is made, in order to investigate acceptance and understanding of evolution theory. It is a report of broader study, whose aim is to highlight the important factors of the conceptual ecology related to evolution theory. Particularly, in this paper we report levels of acceptance and knowledge among teachers and especially science and biology teachers in both countries. A questionnaire was constructed and was applied to a total of 318 Greek and 341 Serbian teachers. In our findings, we mention low levels of understanding of ET, even in biology teachers, in both countries. We also report moderate levels of ET acceptance, with the exception of biology teacher's high acceptance, in both countries. Our results show that Greek teachers performed better on understanding evolution theory in comparison with the group of Serbian teachers, but there is no significant difference between the Greek and Serbian teachers of the acceptance of the evolution theory, as a whole but there are significant differences between various teachers' groups. Significant, but no strong, correlations between acceptance and understanding evolution are recorded; this supports our claim that understanding is a factor of evolution theory's conceptual ecology, but not the more significant one. Findings indicate the necessity to enhance the evolution teaching in both educational systems. Modern biology teaching process for all the levels of education and teachers training, should involve the adequate didactic transformation of evolution content.

Keywords: evolution theory, conceptual ecology, acceptance, knowledge, teachers

RATIONALE, AIM AND OBJECTIVES OF THE STUDY

Evolution theory (ET) is broadly accepted as the central theory of biology, however, despite this, in many countries of the world there exist controversies and the polls show that the acceptance of ET across adult population is restricted (Miller, Scott, & Okamato, 2006). Public understanding of evolution is considered woefully lacking by most researchers and educators. Evolution is considered as concept - threshold that needs to be passed before someone can develop his/her understanding (Kinchin, 2010) of a broader perspective of natural phenomena and of the nature of science. Despite this, educational research has shown that the ET teaching in various parts of the world has not the expected results. Moreover the acceptance of the ET is restricted and the knowledge is limited and controversial among school science students and teachers (Demastes, Good & Peebles, 1995; Deniz, Donnelly & Yilmaz, 2008; Peker, Comert, & Kence, 2009; Nehm, Kim & Sheppard, 2009). High percentages of science teachers reject ET and support the teaching of antievolutionary ideas in schools (Nehm & Schonfeld, 2007). Thus evolution remains a problematic subject for many science teachers.

As teaching and learning evolution in a biology classroom is more than a cognitive-only process and affective factors are evoked more strongly when learning a topic such as evolution, we adopt the claim that conceptual ecologies of both teachers and students influence the process of teaching and learning (Deniz, Donnelly & Yilmaz, 2008). Studying, therefore, the acceptance of ET as a part of the conceptual ecology (Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1992) for biological evolution is more promising than studying the acceptance of evolutionary theory in isolation, due to the fact that, in this theoretical framework, the fundamental importance of intuition, emotion, motives and social factors was acknowledged (Strike & Posner, 1992). Factors that are together called learner's "conceptual ecology" of evolution theory are documented in previous research (Demastes, Good & Peebles, 1995; Deniz, Donnelly & Yilmaz, 2008). They describe that the conceptual ecology for biological evolution contains the following: prior conceptions related to evolution or understanding of ET; scientific orientation (degree to which the learner organizes his/her life around scientific activities); view of the nature of science; view of the biological world in competitive and causal terms as opposed to aesthetic terms; religious orientation, reasoning level; perceptions of the impact of the ET; epistemological beliefs, and thinking dispositions. Deniz, Donnelly & Yilmaz, (2008) added parents' educational level as a factor related to ET acceptance.

There is a need to clarify the terms belief and acceptance, at least the meaning we accept and the way we use them. We do not use the term "belief" as it is considered to be a subjective way of knowing, and it can potentially blur the line between scientific knowledge and religious belief (Sinatra, Southerland, McConaughy & Demastes, 2003). We choose to use the term "acceptance" which is equated with attitude (Ingram & Nelson 2006) and is the most basic attitude toward evolutionary principles and conclusions" (Brem, Ranney, & Schindel, 2003).

According to Smith's review (2010) science education research has taken an interest in the possible relationships among accepting and understanding evolution and particularly if the constructs are correlated or not. In biological domains other than ET, research supports the generalization that knowledge and belief are loosely associated constructs. In the case of ET, in the majority of the studies was found that knowledge and belief are weakly associated constructs though (Smith, 2010). Notably, in some studies was found that knowledge of ET was significantly related to the acceptance of ET.

Build on previous research, this comparative study focused on the factors which make out the conceptual ecology of the evolution theory of Greek and Serbian teachers. From the aforementioned factors we choose to investigate acceptance and understanding –presented in this study in a comparative way - in addition to thinking dispositions, perceptions about the nature of science and religiosity. The following research questions are at issue in this study: (1) to what extent do Greek and Serbian teachers accept and understand the ET? (2) What is the relationship between acceptance and understanding of the ET? Are there differences between Greek and Serbian teachers in this case? (3) What are the differences in acceptance and understanding between teachers of different scientific background in Greece and Serbia? We choose to conduct a comparative study in two ways – between teachers differing in subject matter knowledge and coming from two different countries for two reasons: (1) According to Nehm, Kim and Sheppard (2009), studying biology teachers is a direct and obvious approach for exploring putative associations among subject matter knowledge and belief (and/or advocacy). Broadening sampling strategies to include comparable cohorts of non-biology teachers should be informative. (2) In order to have a better understanding of the conceptual ecology in general, and of the acceptance – knowledge relationship in particular, we choose to develop the same research design in two countries with the same religious orientation. This choice was guided by the findings of previous research that religiosity is an important component of ET's conceptual ecology in Greek cultural frame (author1 & author4, 2011). We hypothesized that there should be differences among people with the same religious orientation but from different cultures, because different socio-cultural backgrounds, religious histories or the traditions of these people.

METHOD

The participants of the study were 318 teachers from Greece and 341 teachers from Serbia. The Greek participants were 78 teachers of Early Childhood Education, 70 Primary Teachers and 152 Secondary Science Teachers (78 Biologists, 24 Physicists, 42 Chemists, 6 Geologists and 2 teachers with other science studies). In this group, women were 61.7% or the sample and the mean teaching experience was 14.9 years (min=1, max=35, SD=9.42). The Serbian participants were 53 teachers of Early Childhood Education, 70 Primary Teachers and 218 Secondary Science Teachers, women were 77,4%of the participants and the mean teaching experience of 16.13 years (min=1, max=38, SD=10.04).

Data Collection was done by the use of the same questionnaire in both countries. The Serbian survey was conducted by personal administration of the research tool to the participants, while the Greek survey was partly web-based and partly personally administrated. The questionnaire was consisted by the next measurements:

Demographics: Teachers responded to five demographic questions which were focusing on gender, age, studies and teaching experience.

Knowledge measure: Teachers' understanding and knowledge of the ET was estimated by means of a scale (adopted from Rutledge & Warden 2000 and adapted for the needs of our study) with 13 questions consisting of two sub-scales. One subscale of 8 questions that had to do with the understanding of very basic principles of the evolutionary theory and was of a Correct-False-Do not know type and the other of 5 multiple choice questions, was concerned understanding of procedures and practices on the evolution of populations. Scoring was performed through a scaling where the correct response to a statement received a score of 1, whereas wrong responses received a score of 0 (Possible total scores min=0, max=13).

Acceptance: To assess students' acceptance of evolutionary theory, we used the MATE scale (*Measure of Acceptance of the Theory of Evolution*), developed by Rutledge and Warden (2000). MATE consists of twenty Likert's -scaled items containing statements that addressed the fundamental concepts of evolutionary theory and the nature of science (Rutledge and Sadler 2007). To score the MATE we follow Rutledge and Warden (1999) procedure, that is: a) to account for positively and negatively phrased items, the scaling of responses were appropriately reversed so that responses indicative of a high acceptance of evolutionary theory received a score of 5, while answers indicative of a low acceptance receive a score of 1. b) An individual's score on the MATE was equal to the sum of the scaled responses of all 20 items.

Data and results processing was performed by applying the basic statistical methods/table-descriptive statistics (means, standard deviations, and maximum and minimum of surveys' responses) with PASW Statistics 18.

FINDINGS and DISCUSSION

Table 1: Acceptance Evolution Theory in Greek and Serbian Teachers

	Greece			Serbia		
	M	**SD**	**SEM**	**M**	**SD**	**SEM**
Acceptance of evolution theory - MATE scale						
Total score *(possible min=20, max=100)*	**76.24**	9.952	0.594	**76.18**	9.821	0.532
Preschool Education Teachers	**72.73**	9.019	1.127	**69,68**	7.450	1.023
Primary Teachers	**75.28**	7.929	0.991	**73.99**	10.214	1.221
Secondary Teachers	**78.38**	10.985	0.942	**78.46**	9.356	0.634
Biology teachers	**80.25**	7.787	0.918	**84.56**	8.099	0.941
Science Teachers except Biologists	**76.25**	13.477	1.684	**75.32**	8.377	0.698
Physicists	**77.15**	8.622	1.928	**71.93**	7.032	0.823
Chemists	**74.31**	16.191	2.699	**78.82**	8.254	0.980

Table 2: Understanding Evolution Theory Greek and Serbian Teachers

Understanding of Evolution Theory

	Greece			Serbia		
	M	**SD**	**SEM**	**M**	**SD**	**SEM**
Total score *(possible: min=0, max=13)*	**7.14**	2.314	0.149	**5.82**	1.949	0.106
Preschool Education Teachers	**6.04**	2.029	0.284	**4.42**	1.715	0.236
Primary Teachers	**6.39**	1.753	0.239	**5.31**	1.814	0.217
Secondary Teachers	**7.95**	10.984	0.941	**6.34**	1.839	0.125
Biology teachers	**8.19**	2.696	0.337	**7.24**	1.542	0.179
Science Teachers except Biologists	**7.70**	2.060	0.260	**5.85**	1.805	0.150
Physicists	**7.25**	1.996	0.446	**5.59**	1.928	0.226
Chemists	**7.64**	2.017	0.331	**6.13**	1.638	0.194

In the tables 1 and 2, we present the mean scores, standard deviations and standard errors of mean, in acceptance and understanding ET scores of all the teachers participated in our study in Greece and in Serbia. We also present the scores, standard deviations and standard errors of mean, both in acceptance and understanding ET, recorded in teachers with different subject matter knowledge i.e. Biologists, Physicists and Chemists.

a) **Acceptance:** Following the categorization developed by Rutledge and Sandler (2007), acceptance levels are moderate in total groups (mean score: 76.24 for Greeks and 76.18 for Serbians), but science teachers of two countries score in high category (mean score: 78.38 for Greeks and 78.46 for Serbians). This high score in secondary teachers is due to Biologists' high score in both countries, also to Greek Physicists' and Serbian Chemists' high level scores (table 1).

Secondary science teachers, in both countries, performed better than their Primary and Preschool Education counterparts. Some of these differences are significant (Greek: Secondary – Preschool Education teachers, mean difference= 5.63, sig<0.01. Serbian: Primary – Preschool Education teachers, mean difference = 4.31, sig<0.05. Secondary – Primary School teachers, mean difference = 4.48, sig<0.01. Secondary – Preschool Education teachers, mean difference = 8.78, sig<0.01.

Biology teachers performed better (mean score: 80.25 for Greek and 84.56 for Serbian) in comparison with other science teacher in both countries. Significant differences in acceptance score are observed: in Greek secondary science teachers between Biologists -

Chemists, mean difference = 6.09, sig<0.05. In Serbian teachers significant differences are observed between Biologists – Chemists, mean difference = 5.75, sig<0.01, Biologists – Physicists, mean difference =12.64, sig<0.01.

Greek teachers, totally, score higher in comparison with Serbian teachers, but this difference is not significant. Also, there is a difference between Greek and Serbian biology teachers in favor of Serbian, but this difference is not significant. Significant differences in acceptance scores are observed between: Greek – Serbian Biologists, mean difference -4.32, sig<0.01, Greek – Serbian Physicists, mean difference 5.21, sig<0.01.

b) **Understanding:** In both countries understanding levels are very low (mean score: 7.14 for Greek and 5.82 for Serbian teachers) (Table 2).

Secondary science teachers, in both countries, performed better in understanding score than their Primary and Preschool Education counterparts (Table 2). Some of these differences are significant, particularly: in Greeks Secondary – Preschool Education teachers, mean difference=1.91, sig<0.01 and Secondary – Primary Education teachers, mean difference=1.56, sig<0.01. In Serbians, Secondary – Preschool Education teachers, mean difference=1.91, sig<0.01, Secondary – Primary Education teachers, mean difference=1.01, sig<0.01 and Primary – Preschool Education teachers, mean difference=0.90, sig<0.05.

Biologists' score in understanding ET is slightly better than the other teachers groups, but their score levels are still low. Specifically, there are not significant differences between Greek science teachers with various scientific backgrounds. In Serbian teachers, there are significant differences in understanding score between: Biologists – Physicists, mean difference =1.65, sig<0.01 and Biologists - Chemists, mean difference =1.12, sig<0.01.

Higher scores were observed by groups of Greek teachers in comparison with groups of Serbian teachers. The majority of these differences are significant, specifically: Greek – Serbian Secondary teachers: Mean difference 1,619, sig< 0.01, Greek – Serbian Primary teachers: Mean difference 1.08, sig<0.01, Greek – Serbian Kindergarten teachers: Mean difference 1.62, sig<0.01. Also significant differences are observed between: Greek – Serbian Physicists: Mean difference 1.66, sig<0.01 and Greek – Serbian Chemists: Mean difference=1.52, sig<0.01

c) **Correlations:** There are positive significant correlations between understanding and acceptance of evolution theory, both in Greek (r=0.248, p<0.01) and Serbian groups of teachers (r=0.353, p<0.01).

In comparison with other studies which investigate acceptance of ET (measured with MATE scale), results of Greek and Serbian teachers are very similar to the Oregon biology teachers who achieved 85.90 for mean score of acceptance (Trani, 2004). Turkey preservice biology teachers achieved only 50.95 for mean score of acceptance (Deniz, Donnelly, & Yilmaz, 2008), and Indiana biology teachers achieved 77.59 for mean score of acceptance (Routledge & Warden, 2000). These are low achievements in comparison with results of Greek and Serbian teachers.

Taking into account the other categories of teachers, secondary and primary school teachers from New Zealand achieved 84.55 for mean score of acceptance (Campbell & Cook, 2003), which is very similar to the results of Greek and Serbian biology teachers. Non biology majors from United States achieved only 55.87 for mean score (Rutlege & Sadler, 2007).

Our results indicate that there is a positive correlation between acceptance and understanding ET. Also, there are some other studies, which have shown positive correlations between acceptance and understanding (Rutledge & Warden, 2000). But, there are some others which have found no statistical relationship between these variables (Demastes, Good & Peebles, 1995; Brem, Ranney & Schindel, 2003; Sinatra, Southerland, McConaughy & Demastes, 2003).

CONCLUSIONS AND IMPLICATIONS

Based on results, presented for the Greek and Serbian groups of teachers, it can be concluded that there is no statistically significant difference between the groups of Greeks and Serbian (as a whole) in acceptance of evolution theory.

Also, we can see that there are significant differences (in total score) between the Greek and Serbian teachers for understanding ET. Greek teachers score is higher than their Serbian colleagues both in acceptance (no significant) and in understanding (significant).

We maintain that differences in understanding ET between Serbian and Greek teachers exist due to differences between the two educational systems.

Greek and Serbian biology teachers have higher scores for understanding and acceptance in comparison with the other science teachers. It can be explained by the existing of evolution teaching content on their studies.

Generally speaking, it seems that understanding goes with acceptance, that means cohorts with higher understanding score shows also and a higher score of acceptance, but there are two exceptions: Serbian Biologists and Chemists. Greek teachers score higher than their Serbian colleagues both in acceptance and in understanding, with two exceptions: Serbian Biologists and Chemists. In this case, our initial hypothesis that there should be differences among people with the same religious orientation but from different cultures seems to be true.

There are positive correlations between knowledge and acceptance for Greek and Serbian groups of teachers. Weak and moderate, even significant, correlations between acceptance and understanding indicate the need to investigate other factors of conceptual ecology of ET. Finally, these levels of understanding ET represent a challenge that educational systems in both countries need to address in order to provide legitimate biological education.

There is a need to change and transform didactically ET content, in both countries, especially in textbooks and courses. Teachers in both countries would benefit from more training in evolutionary science and also in methods of transforming and teaching ET content. There is a need of training in evolution for Primary and Preschool Education Teachers too. Primary teachers in both countries are teaching about living organisms and their adaptations and evolutionary perspective is a necessary condition for effective teaching. Finally evolutionary perspective is very possible to influence the kind of the narratives that kindergarten teachers adopt about living organisms and their history in the Earth.

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CHILDREN'S BIOLOGICAL CONCEPTIONS BEFORE AND AFTER INSTRUCTION

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Abstract: Several studies have showed that children initially discriminate living things and nonliving things according to perceptual characteristics. They also make mistakes in categorizing living and nonliving things according to the corresponding ontological categories and in using the biological functions of organisms as systematic criteria to discriminate them.
This paper describes the results of an empirical study focused on the biological conceptions held by children aged from 4 to 6 years. It also describes the conceptual change as a result of instruction based on constructivist teaching. Our findings showed that younger children correctly attributed the ontological categories animals and nonliving things, but they did not automatically assign the biological properties to the item classified as living. Moreover, after the instruction we observed a significant improvement in sorting animals and plants as living and in the attribution of biological properties to the living things.

Keywords: Biological conceptions, conceptual change, active learning, primary school, preschool.

INTRODUCTION

Children's ability to distinguish between living and nonliving things has been extensively studied by psychologists and educational researchers (Hatano & Inagaki, 1997; Caravita & Falchetti, 2005). Authors emphasize that during the school age, children have not still developed their biological conceptions according to the scientific accepted theories and that their conceptions about natural phenomena may differ from those of scientists (Carey, 1985). For an adult, considering an entity as alive also means attributing to it some biological properties which are typical of the living things (such as growth, eating, breathing), while a child may not use biological properties as a criterion to distinguish living and nonliving things, as some authors suggested (Gutheil *et al*., 1998; Inagaki & Hatano, 2002). Some authors hypothesized that children's difficulty in discriminating living and nonliving things could arise from mistakes made by children when attributing concepts to one of the three ontological categories – matter, processes and mental states – among which they make an early classification of the reality (Chi *et al*., 1994). Many studies which focused on children's ability in discriminating between living (animals and plants) and nonliving things, showed that, from a developmental perspective, children consider plants as a sub-category of the living domain later than animals (Inagaki & Hatano, 1996; Labrell & Charlieux, 2009; Nguyen & Gelman, 2002; Richards & Siegler, 1984). From an educational point of view many researchers emphasized that instructional activities based on an active and cooperative learning were effective in promoting an early understanding of biological concepts in children (Nigris, 2007; Niemi, 1997; 2002).
From a methodological perspective, in the cited studies, animals, plants and inanimate objects were rarely involved at the same time. Moreover, children are generally asked with questions

which require a yes/no answer (Carey, 1985) or with open-ended questions sometimes following an explanation of a given property (Inagaki & Hatano, 1996). In our opinion, for a young child, answering a question implies not only to recall the proper information, but also to be able to construct a verbal response: given the young age of the interviewed children, it is likely that their verbal ability is still immature and that could therefore affect their responses. Besides, some authors stressed out that some questions may appear ambiguous to the child (Hatano & Inagaki, 1996). We thus decide to use a sorting task with pictures for collecting data which are not influenced by young children's poor ability in speaking. Therefore, aims of the present study are: a) to describe the understanding of children between 4 to 6 years concerning the categories of living, nonliving, animal, plant and their biological properties; b) to assess the conceptual change which emerged further to an instructional program.

METHOD

The participants were 68 children: 37 preschoolers (17 girls, 20 boys, mean age 5.3 years) and 31 first-graders (16 girls, 15 boys, mean age 6.7), coming from five different classes of two public schools located in Rome (Italy). Three age levels were considered: 4-year-olds (5 girls, 8 boys); 5 year-olds (10 girls, 11 boys); 6-year-olds (18 girls, 16 boys). The entire sample was divided in two subgroups: the experimental group, constituted by 24 preschoolers (12 boys, 12 girls, mean age 5.3) and 17 first-graders (10 boys, 7 girls, mean age 6.6), and the control group constituted by 13 preschoolers (8 boys, 5 girls, mean age 5.3) and 14 first-graders (5 boys, 9 girls, mean age 6.8). To assess children categorization of living things and biological properties attribution, we administrated our sample with a task using 9 photo-cards, showed in Figure 1. They represented: a) animals: a dog, a fly, a starfish; b) plants: a common European species of daisy (*Bellis perennis*), an oak tree (*Querqus sp*), grass; c) nonliving things: a stone, a bike, a teddy bear. During the task, children were asked to sort the cards in living, nonliving things, animal, plant, and to attribute them seven biological properties: birth, growth, eating, breathing, reproducing, falling ill, and death.

Figure 1. Materials of the sorting task.

Children responses were coded as correct (0) or incorrect (1). The dependent variables used were the scores of the correct sorting of animals, plants and things as living (each one with a

0-3 range), a score for animals and plants correct categorization as living (range 0-6), a score for the correct attribution of biological properties to animals and plants (score 0-6) and a global score for the correct attribution of biological properties (range 0-9).
With respect to the first aim, we conducted descriptive analysis considering the whole sample grouped by age levels. We also conducted two ANOVAs: one with Age (3) and Category (3) as factors; the other with Age (3) and Property (7) as factors. With respect to the second aim, we analyzed the effectiveness of instruction by comparing children's knowledge before and after the instructional program with that of the control group. We therefore conducted ANOVA analyses with Group (experimental vs. control) and Time (pre-test vs. post-test) as factors.

Instructional program

Teaching was displayed for the experimental group only, while the control group did not receive any instruction on the same contents. The instructional program lasted 8 weeks, for a total of 52 hours. Pupils worked in a learning environment in which they could found living organisms so that they had the possibility to improve experimental observations. The training, as showed in Table 1, was characterized by direct observations on living plants and animals, the use of drawing as a tool to describe the natural objects, and was based on cooperative learning activities (for example, group discussions, group hypothesis testing).

Table 1. Characteristics of the instructional program

Characteristics	Unit 1: Plants	Unit 2: Animals
Aims	To distinguish living and nonliving things To classify plants and animal To attribute biological properties to living things	
Contents of learning	Living and nonliving things Seven biological properties: birth, growth, eating, breathing, falling ill, reproducing, dying	
Investigated objects	Flower, Pine Seed, Grass, Bean, Lentil	Ant, Snail, Earthworm
Lab activities	Collecting samples, Observation, Description, Sorting	
	Seeding under different environmental conditions. Discussion	Breeding Discussion
Educational methodology	Constructivist Approach Scientific Method	
Educational strategies	Personal and group investigation Working in natural environment Naturalistic drawing	
Evaluations	Tasks	

RESULTS

With respect to the first aim, we analyzed children sorting of animals, plants and nonliving things and how they correctly attributed to them the biological properties. Considering the whole sample, a higher percentage of children sorted animals as living than plants (respectively, 84% against 59%). Nonliving things were correctly sorted by the majority of the children (78%). ANOVA analysis showed an Age x Category interaction [$F(4, 130) = 2.473$, $p = .048$; see Figure 2] and post-hoc analyses revealed that: 5- and 6-year-olds scored significantly better in sorting animals than 4-year-olds; 6-year-olds produced more correct sorting for nonliving than 4- and 5-year-olds.

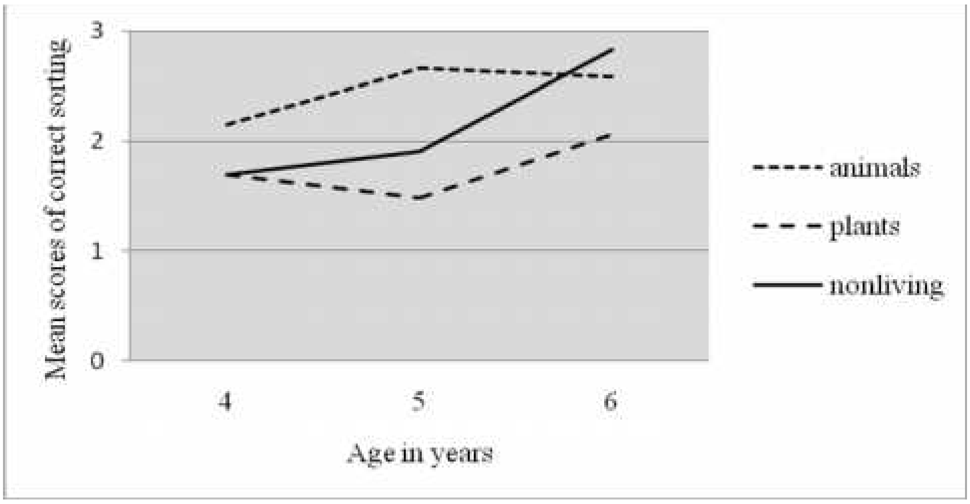

Figure 2. Children's correct sorting of animals, plants and nonliving things at 4, 5 and 6 years old.

The same analyses also showed that 5-year-olds scored significantly better in sorting animals than plants and nonliving, and that 6-year-olds produced more correct sorting for animals and nonliving than for plants. Thus, children's conceptualization of living and nonliving increases with age for animals and nonliving but not for plants. Concerning the biological properties, even if 75% of children correctly did not attribute them to nonliving things, only 27% of them assigned such properties to plants and 25% to animals. We found a significant Age x Property interaction [$F(12, 390) = 2.881$, $p = .001$]. Post-hoc analyses revealed that the attribution of birth, reproducing and dying properties significantly increase with age (see Figure 3).

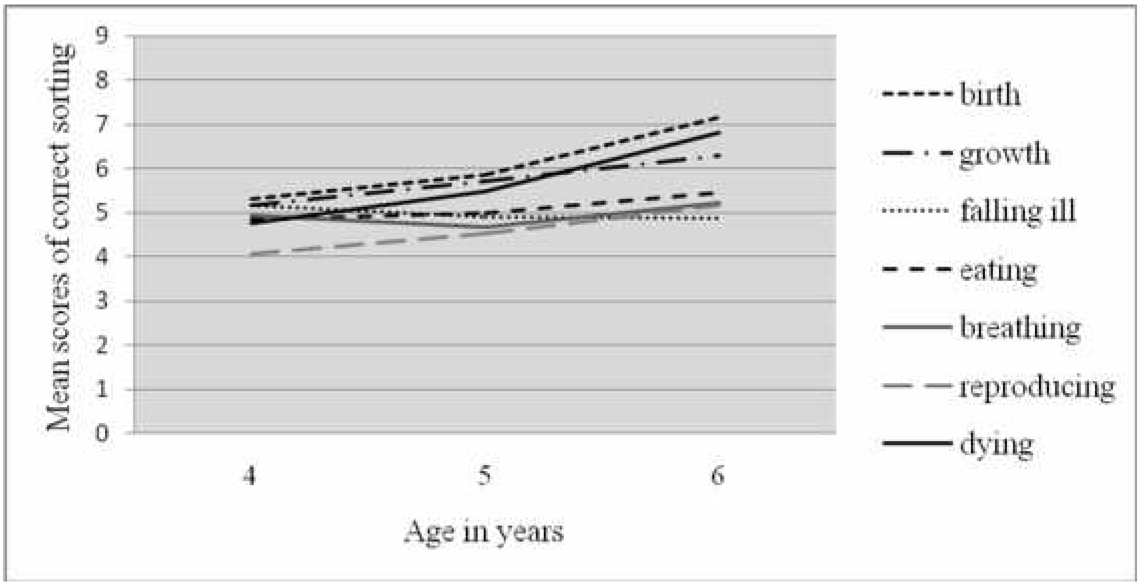

Figure 3. Children's correct attribution of biological properties at 4, 5 and 6 years old.

Moreover, 4-year-olds did not show any difference in properties attribution, whereas 6-year-olds scored significantly better in attributing birth, dying, and growth than the other properties.
With respect to the second aim, to assess the effect of instruction we conducted, separately for preschool and first-grade children, analyses of variance calculated on the score for the correct categorization of animals and plants as living and for properties attribution to them considering as factors Groups (experimental vs. control) and Time of assessment (pre-test vs. post-test). Only significant interactions were considered, as they showed a teaching effect in experimental group. We did not considered the simple effects of Group and Time. As shown in Table 2, the correct sorting of animals and plants as living things increased significantly after the instructional program both for preschoolers and for first-graders. After the instruction, first-grade children also improved in correctly attributing all the biological properties to animals and plants, while preschool children only improved in correctly attributing the breathing and dying properties. A tendency was also observed after the instructional program in preschoolers' attribution of birth and eating properties.

Table 2. Anovas results for the Group x Time interaction

Category and properties correct attribution	Children group: Preschool	Children group: First-grade
Living	$F = 6.338$, $p = .017$	$F = 12.161$, $p = .002$
Birth	$F = 3.801$, $p = .059$	$F = 6.898$, $p = .014$
Growth	$F = .042$, $p = .838$	$F = 9.920$, $p = .004$
Falling ill	$F = 3.701$, $p = .063$	$F = 10.642$, $p = .003$
Eating	$F = 3.815$, $p = .059$	$F = 24.802$, $p < .001$
Breathing	$F = 6.792$, $p = .013$	$F = 24.109$, $p < .001$
Reproducing	$F = 3.310$, $p = .077$	$F = 7.690$, $p = .010$
Dying	$F = 13.097$, $p = .001$	$F = 5.365$, $p = .028$

DISCUSSION AND CONCLUSION

As we noted in the introduction, studies which focused on children's understanding about living things often analyzed separately animals, plants and inanimate objects, or compared living things using inanimate objects as distracters. Our research is one of the first analyzing at the same time children's understanding about the two sub-categories of living (plants and animals) and the nonliving category in children between 4 and 6 years of age. Moreover, we also analyze if they correctly attributed the biological properties.
Our results show that children's categorization of living things increase with age, with less difficulties to sort animals than plants, as previously shown (Richards & Siegler, 1984; Inagaki & Hatano, 1996; Nguyen & Gelman, 2002; Labrell & Charlieux, 2009).
Children of our sample were not able to attribute biological properties to all object classified as living. An explanation could be the different criteria to discriminate between animate and inanimate objects that children use, as Gutheil (1998) and Inagaki and Hatano (2002) suggested. Only the ability to attribute the birth, reproducing and dying properties significantly increases with age. Children improved in generalizing to several examples properties for which they have little or no direct experience, like birth, reproducing and death. One possible explanation of these results could be that children early understand those properties which are often objects of explanations from adults. In the family, but also at school, children receive explanations and listen narratives about birth, reproducing and death

which could help them to understand such processes earlier than of which they have more experience and that are less objects of adults explanations (such as breathing, eating, etc.). It is thus therefore possible to argue that children's knowledge, particularly for some biological properties and processes, do not only arise from personal experience, but also by cultural transmission.
After the instructional program, only first-grade children appeared to clearly differentiate living and nonliving things in terms of biological properties, since they assigned all the investigated biological properties to all the items sorted as living. Our results therefore suggest that after instruction, preschoolers improve in categorizing animals and plants as living, but it is only by age six that children appear to attribute the biological properties to all the living things. It means that the planned instructional program was effective in driving children's understanding to higher levels, but we have to verify the possibility to modify the program in order to be more effective for younger children.
In this research we used a task which did not require children to verbally answer a question but to choose from a set of images. The conceptions we found using this task were similar to those already described in literature. Moreover our non-verbal task was capable of capturing changes in the development of conceptions across ages, and to assess the conceptual change after the instruction. From an educational perspective, it seem also relevant to detect children's understanding before and after the instruction using structured tools, in order both to adapt the instructional intervention to conceptions really held by the children, and to assess the effectiveness of teaching.

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CHINESE AND AUSTRALIAN CHILDREN'S UNDERSTANDING OF THE EARTH: A CROSS CULTURAL STUDY OF CONCEPTUAL DEVELOPMENT

TAO Ying, OLIVER Mary, VENVILLE Grady

Abstract: The purpose of this study was to explore Chinese and Australian primary children's conceptual understandings of the Earth. Participants were Year 3 and Year 6 children from three schools in Hunan Province, central south China (*n*=275) and Year 3 and Year 6 children from three schools in Western Australia (*n*=225). The children's general understandings were assessed by a science quiz developed from the past TIMSS science. In-depth interviews were carried out with a total 38 Chinese children and 36 Australian children to further explore their conceptual understandings of the Earth's shape, gravity, day/night cycle and seasons. The results showed that, regardless of different cultures, children from the same age group constructed similar concepts about the Earth. The Year 3 children tended to demonstrate intuitive conceptions of a round and flat Earth. The Year 6 children were more likely to demonstrate consistent understandings of a spherical Earth. Universality and cultural mediation in children's understanding of the Earth are discussed and a model of conceptual development is proposed.

Keywords: primary children, Earth science, cross-cultural study, China, Australia

Figures

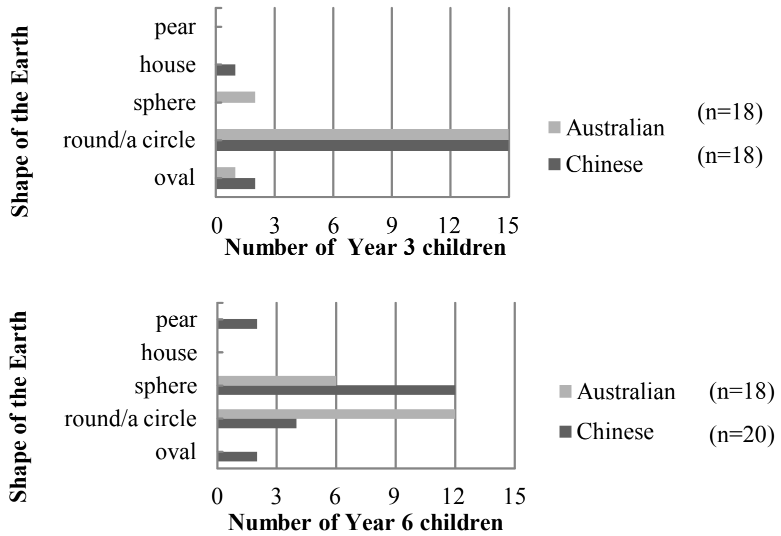


Figure 1. Year 3 and Year 6 children's responses to the shape of the Earth

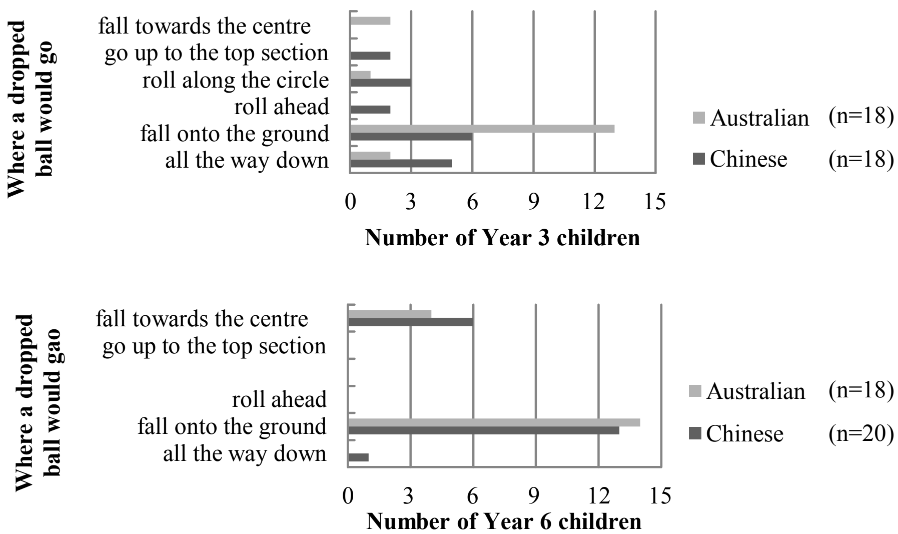


Figure 2. Year 3 and Year 6 children's responses to where a dropped ball would go

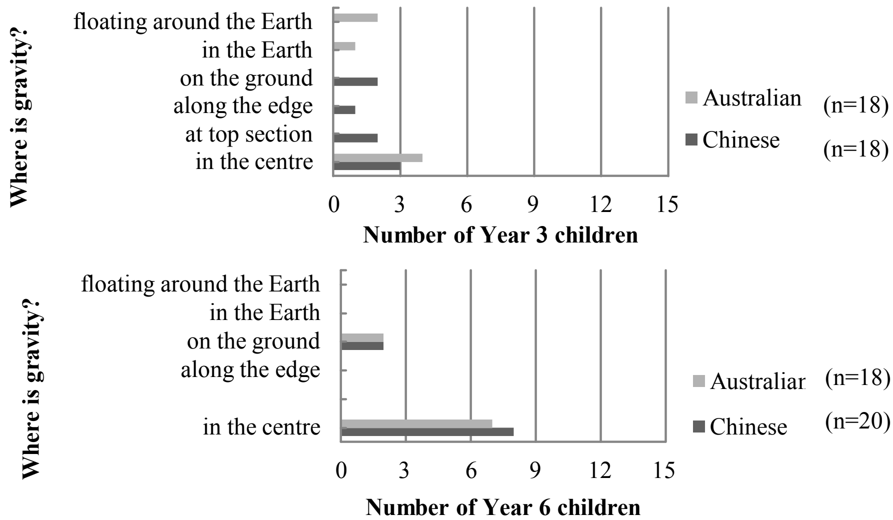


Figure 3. Year 3 and Year 6 children's responses to where gravity is

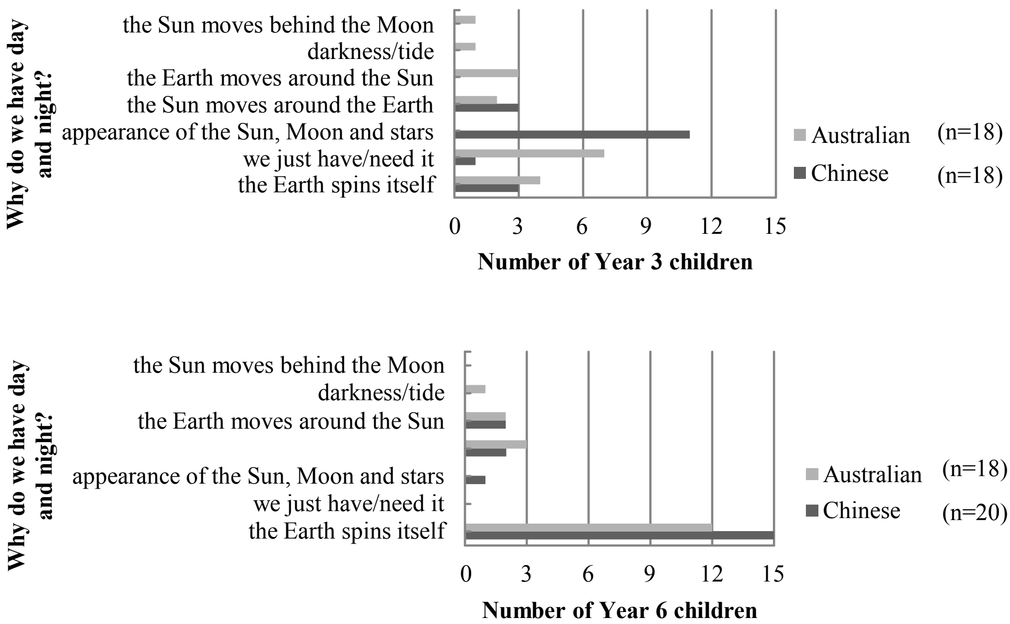


Figure 4. Year 3 and Year 6 children's responses to the main cause of day/night cycle

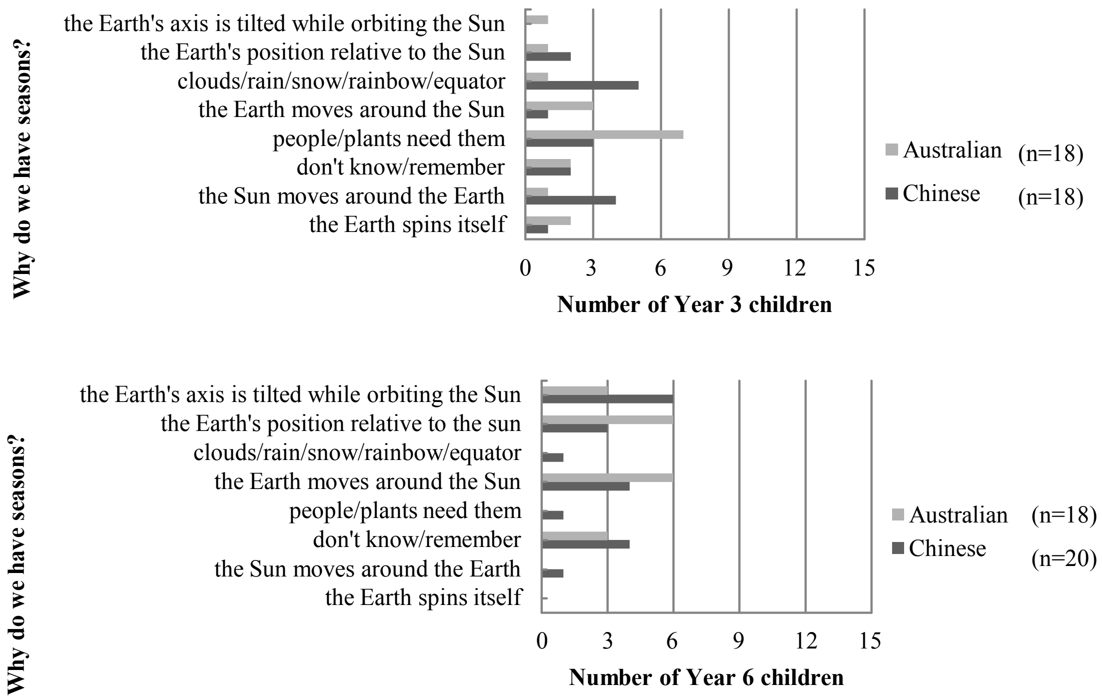
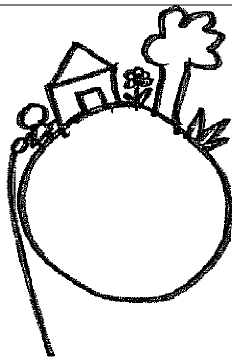
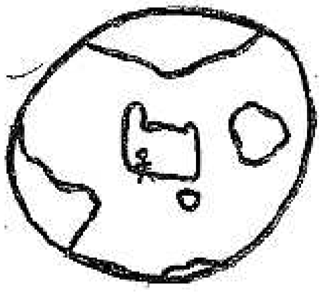


Figure 5. Year 3 and Year 6 children's responses to the main cause of season

Category	Description	Examples of Children's Drawing	Year 3 (n=36)	Year 6 (n=38)
A	Earth is round and flat with an edge. people live on the ground within the edge. a dropped ball would fall down to the ground. day/night cycle occurs because the Sun and the Moon move around the Earth. seasons occur because we just have/need them.		Yu Xin[C1Yr3] Long Lin[C1Yr3] Tang Zhuo[C1Yr3] Ming Hui[C2Yr3] Mannahil[A1Yr3] Natasha[A2Yr3] Clayton[A2Yr3] Michael[A3Yr3] Blaze[A3Yr3]	N/A
B	Earth is round like a ball. people only live on the top section of the Earth. a dropped ball would fall down to the other end of the Earth, or roll along the curve of the Earth. day/night cycle occurs because of the appearance of the Sun and the Moon. seasons occur because the Sun rotates around the Earth.		Peng Qian[C3Yr3] Zi Yi[C3Yr3] Jia Yi[C3Yr3] Johanna[A2Y3] Shaylah[A3Y3]	N/A
C	Earth is round like a ball. people live on the bottom or the sides of the Earth, but not the top section (e.g. the Earth spins upside down) a dropped ball would fall down to the ground. day/night cycle occurs because the Earth spins around. seasons occur because the Earth revolves around the Sun.		Luke[A2Y3]	Jordan[A2Yr6] Megan[A2Yr6]
D	Earth is round like a ball. continents and oceans are inside the Earth and people live on the Earth. People would not fall off as long as they hold onto the Earth. a dropped ball would fall straight down, or go up to the top section. Day/night cycle occurs because the Earth rotates around the Sun. Not sure about why seasons occur.		Jiang Ying[C1Yr3] Jia Hao[C2Y3] Xian Yu[C2Yr3] Yang Jing[C3Yr3]	Xiao Yan[C3Yr6] Wu Bo[C3Yr6]

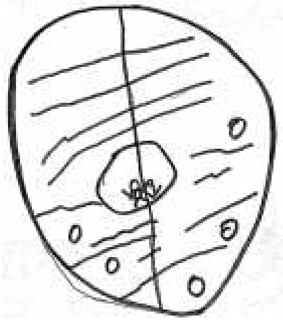
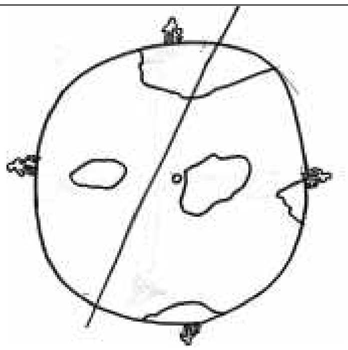
E	Earth is round like a ball. continents and oceans are on the surface of the Earth, people live inside or in the middle of the Earth. a dropped ball would falls down and continue to fall to the centre of the Earth if there is a deep hole. day/night cycle occurs because the Earth spins on its axis. seasons occurs because the Earth orbits around the Sun/the Sun spins.		Pang Yi[C2Yr3]	Jia Yi[C1Yr6] Wan Lu[C1Yr6] Zhi Yong[C2Y6] He Chang[C2Yr6] Tess[A1Yr6] Alex[A2Yr6] Rebecca[A3Yr6] Jacob[A3Yr6] Denai[A3Yr6]
F	Earth is a sphere without an edge. people live all over the curved surface. a dropped ball always falls towards the centre of the Earth. day/night cycle occurs because the Earth spins on its axis. seasons occurs because the Earth orbits around the sun and Earth's position relative to the Sun during its revolution.		Liu Yu[C1Yr3] Yi Fei[C1Yr3] He Wei[C2Yr3] Yang Le[C3Yr3] Jia Xiong[C3Yr3] Jamie[A1Yr3] Eric[A1Yr3] Madeline[A1Yr3] Henry[A1Yr3] Charlie[A2Yr3] Megan[A2Yr3] William[A3Yr3] Abby[A3Yr3] Copper[A3Yr3]	Wen Xuan[C1Yr6] Zheng Ke[C1Yr6] Hong Wei[C1Yr6] Xiao Yuan[C2Yr6] Zhao Qing[C2Yr6] Li Da[C2Yr6] Pang Bo[C3Yr6] Peng Pei[C3Yr6] Ming De[C3Yr6] Emily[A1Yr6] Alistair[A1Yr6] Kathy[A1Yr6] Daina[A2Yr6] Grace[A2Yr6] John[A2Yr6] Tegan[A3Yr6] Matthew[A3Yr6]
G	Earth is a sphere without an edge. people live all over the curved surface. a dropped ball always falls towards the centre of the Earth because of gravity. day/night cycle occurs because the Earth spins on its axis. seasons occur because the Earth's axis is tilted while it's orbiting around the Sun.		Alice[A1Yr3]	Yi Jie[C1Yr6] Xiong Chen[C2Yr6] Lin Cong[C2Yr6] Zhou Chao[C2Yr6] Tian Peng[C2Yr6] Thomas[A1Yr6] Andrew[A2Yr6] Daniel[A3Yr6]

Figure 6. Examples of Yea 3 and Year 6 children's conceptual understanding of the Earth

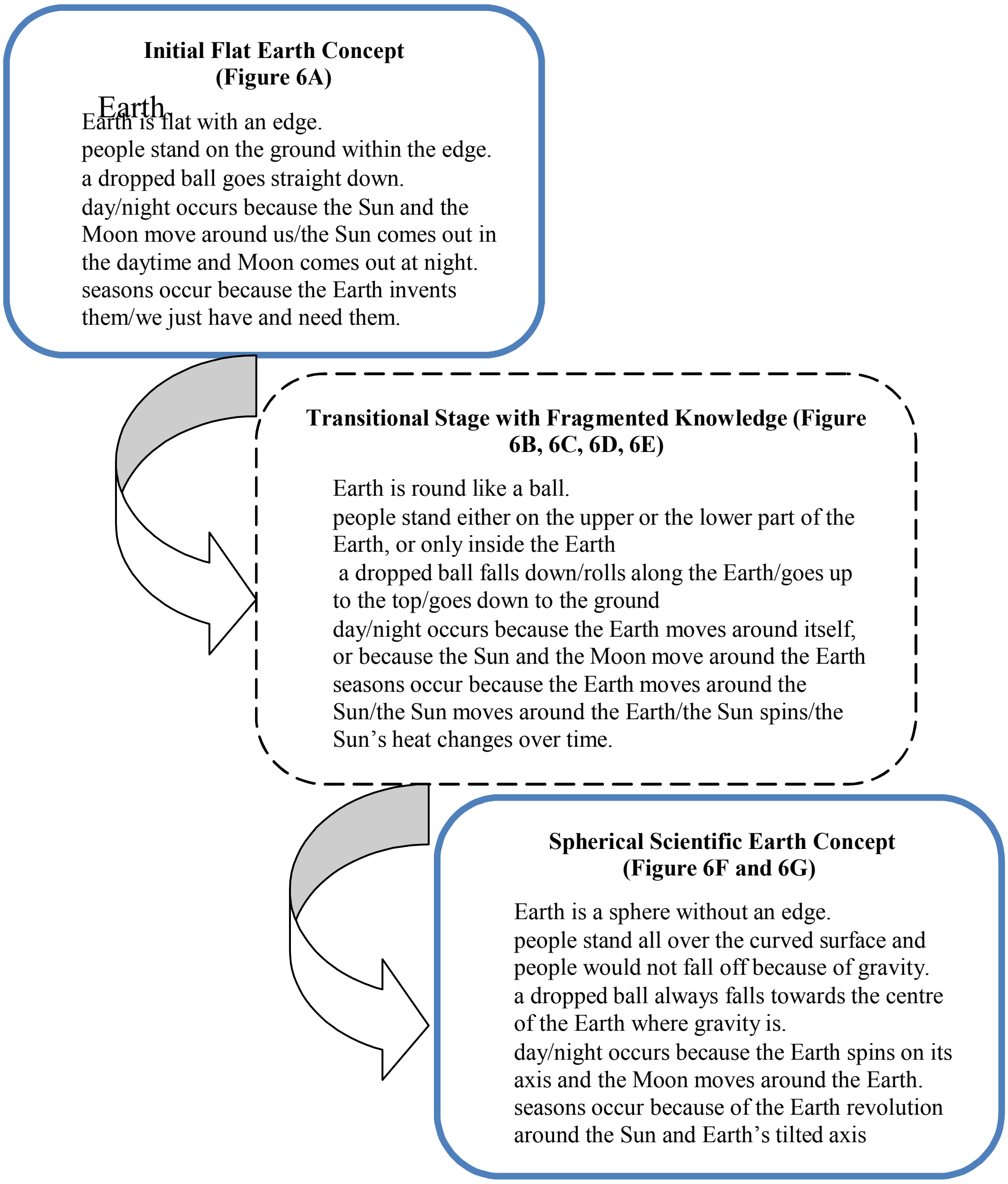


Figure 7. A representation of the pathway of children's conceptual development of the Earth

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HOW 16 YEARS OLD STUDENTS DEAL WITH ELECTRICITY CONCEPTS IN INQUIRY SITUATION

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Abstract: This paper reports a case study where a small group of 16 years old students is engaged in a productive and collaborative process through a SCY mission. This group designs and performs experiments on electricity, processes data, makes calculations, interprets the results and produces documents. From screen and audio records analysis, we look for what these students do with electricity concepts. Occurrences of concepts are coded to specify their characteristics and context of usage. We observe that the students very often encounter and mobilise the electricity concepts all along their work. This is partly due to recurrent difficulties. A comparison of the way students and teachers name concepts shows that the semiotic form of concepts' occurrences is an indicator of the students' mastery of the concepts. Most of the students' difficulties concentrate on physical quantities units and it leads the students to debate about the meaning of units and of the related physical quantities, and about the mathematical relation between concepts. These students also had problems using the web freely to search information. The role of teachers looks fundamental in this case: they guide the students to step out dead ends and to stay in a productive path, and they validate the students' work to support them to go on.

Keywords: Inquiry learning, Conceptual knowledge, Electricity, Web information search, Semiotic form

INTRODUCTION

In the SCY (Science Created by You) project (de Jong et al, 2010), the students are engaged in missions about socio-scientific topics, where they have to build objects (named ELOs, Emerging Learning Objects) following an inquiry and collaborative scenario. To create these objects, the students have to collect and organize information, design and perform experiments, process data, make interpretation, communicate their results and conclusions. One main assumption is that students' engagement in such active processes favours the acquisition of knowledge and skills. These pedagogical approaches can be efficient for developing social skills and scientific knowledge. Such pedagogical situations are not easy to build and organise (Puntambekar & Kolodner, 2005). In particular, careful scaffolding and guidance are often necessary (for a review see Hofstein & Lunetta, 2003).

RATIONALE

We are interested in how students encounter conceptual knowledge when they are engaged in the inquiry process of a SCY mission. We look for what students do with scientific concepts, for their needs and difficulties, and for the conditions that have an effect on the students' use of concepts. We do not want to test if students do learn concepts, but we seek for cognitive activities and for obstacles that may contribute to or hinder learning processes.

The SCY mission is to design a CO_2-friendly house, a family house with a carbon footprint as small as possible. The students work in groups of three, called design groups. The pedagogical scenario of the mission is organized in a jigsaw pedagogical approach where the students change roles and switch between their design group and an experts group: each student of a design group becomes a member of an experts group. An experts group has an expertise role in a specific domain (energy expert, thermal expert, domestic use expert) and has to explore the domain on a defined topic and make a report to the design groups.

As experts, a group of students has to deal with scientific concepts through a complete scientific process: setting questions, designing and conducting experiments, processing data, making interpretations and conclusion, reporting their work both in a written and oral form to their design group workmates. We present here a case study for a group of students working on electricity questions (domestic use experts). These students choose to evaluate the energy consumption of a TV with or without sleep mode; for this purpose, they have to measure power in order to calculate the energy using E= P*t law, and then compare values. These electricity concepts have been taught at a lower class level. We observe that these students are familiar with these concepts without mastering them.

DATA

The data are collected during the first trials of this SCY mission, with French students of 16 years old. The students work in experts' groups of 3 for about 5 hours on their own topics. Screen recorded data of students' activities on the computer, audio records, students' productions (ELOs) are collected.

METHOD

The screen/audio records are synchronised and then coded with a video coding software. A set of coding variables is used to characterise the occurrences of concepts used by the students according to our research questions. The records are coded separately by two researchers and the differences of coding are compared to reach an agreement.

We want to trace the way students use electricity concepts. By concepts we mean essentially the physical quantities. This is appropriate regarding the tasks that these students are performing here. Each word (or group of words) in the verbalizations matching up to a physical quantity is taken as an occurrence and each occurrence is characterized by its semiotic form. Tagging an occurrence with its semiotic form broadens the point of view about concepts: for instance we can take into account occurrences that cannot be considered as a physical quantity with certainty. Sometimes the semiotic form does not correspond to the standard scientific forms required for physical quantities, such as the physical quantities names, the usual symbols, the numerical values and units: the speaker may use a vague form or an inappropriate name: "it", "this", "electricity", "consumption", … In such cases it is not always possible to relate the occurrence to a well defined physical quantity and it can be categorized as "undefined".

A first set of questions is related to the occurrence of concepts: do students encounter and mobilize electricity concepts? Which concepts occur? We thus look for all occurrences of the electricity concepts. Figure 2 gives the list of the concepts encountered.

A second set of questions is devoted to the characterisation of the occurrences of concepts and of the working context. We characterise an occurrence of a concept by indicating who is the speaker, who introduces the occurrence (figure 1), what is the semiotic form of the occurrence (figure 3 gives a list of the semiotic forms used), if the occurrence participates to a relation between concepts, what is the grammatical mood of the occurrence, … For the working context, we take into account which tasks/activities are being performed, and with which persons, tools or resources do students interact?

The analysis of coded variables follows four directions. The first one is to look globally at each variable. At a second stage we look at the evolution of the way the students use the concepts. Another point of view is to cross the context variables with the occurrences of the concepts in order to determine a possible influence of the context. The analysis of the coded variables is also used to select records extracts for written transcription in order to perform a detailed analysis.

For example we look for the occurrences of the concept "electrical power". For one occurrence of this concept, the coding variables indicate that the "speaker" is "the students", that the one who introduces the occurrence is also "the students", that he refers to power using a unit (kilowatt) … About the context, we note that this occurrence occurs during data processing, using the data processing tool and that the teacher is not participating. This occurrence is one of the occurrences that we take into account when looking for the changes of semiotic form of electrical power during the students' work …

RESULTS

There were troubles with the school network and SCY-Lab, which provides the electronic environment of the mission to the students, was often not reachable. Therefore the students often had to use other tools and other resources than those designed for the mission. The students' environment was changed, providing unexpected and less controlled working conditions. The students used standard electronic tools, the scaffolding was mainly done by the teachers and the students turned to use internet their own way to seek for information instead of using the mission resources. As a consequence the teacher was very often in interaction with the students (30% of the whole sequence duration). This was not expected for this learning situation, but on the other hand we are able to compare the ways teachers and students use concepts.

Concepts mobilisation

The students mobilise the electricity concepts all along the working sessions. We observe periodic increases of occurrences of concepts at almost any stage of the students' work. However occurrences of concepts are numerous at all stages of the work except for the first 50 minutes when the students start with the problem and consider experiment design. The total number of the occurrences of electricity concepts is 680 over the 250 minutes of analysed records.

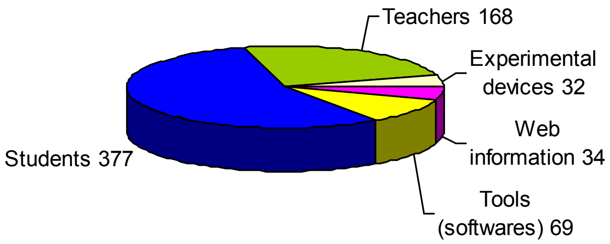
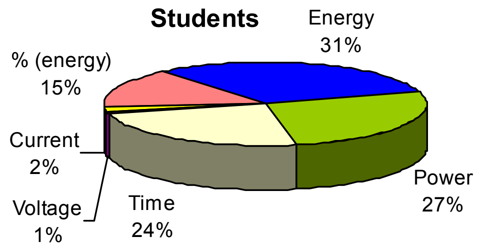


Fig 1: An occurrence of an electricity concept can be introduced by various participants. It can be introduced by a human participant such as students and teachers, as well as by a device or a document that the students use. For instance an occurrence of power is introduced by a document if a student reads and discovers it on the document, even if the true speaker is the

student. The number of occurrences is indicated for each participant.

Figure 1 shows that the number of occurrences due to the students (54%) is almost always more important than for any other source at any stage of the work. Occurrences are often brought by the teachers (25% of all occurrences) or by documents, tools and devices (20%). Lots of occurrences are probably due to the activities performed: measuring, seeking for information, making calculations … But this does not explain the abundance and regularity of the occurrences of concepts all along the work. In fact the students encounter strong and recurrent difficulties about concepts.

The students and the teachers use the same concepts. Furthermore they use a given concept in the same proportion compared to the occurrences of the other concepts: for instance the proportion of energy occurrences is about 30% of total concepts occurrences for both the students and the teachers.



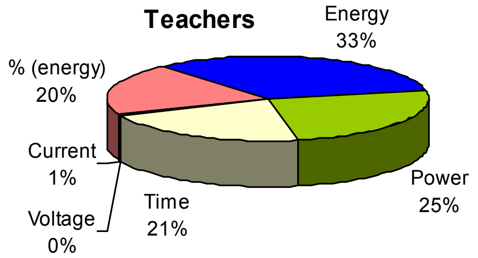
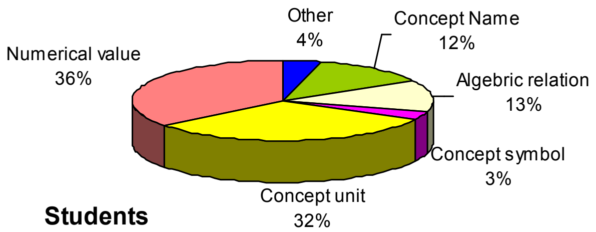


Fig 2: Comparison of electricity concepts mobilized by the students or by the teachers.

Semiotic form of concepts

On the other hand, the semiotic form of the occurrences of concepts is quite different for the teachers and the students (figure 3): the predominant form for the students is unit (32%) and numerical value (36%) since the scientific name of concepts is used only for 12%. For the teachers, the concepts name is 31%, unit 17% and numerical value 25%. A priori we may think that this can be due to the fact that the students and the teachers have different aims, since the teachers' main job is to guide the students while performing experiments, doing calculations … Despite this fact, the study of verbalisations shows that the students often use the unit name instead of the concept name. For instance one boy explained "there are several watts: there is the total watt, the sleep mode watt and the working mode watt", using the unit name watt instead of the concept name, power. In this example, the students discuss about power as if it was energy, suggesting that one can sum the power quantities in the same way than the energy quantities.



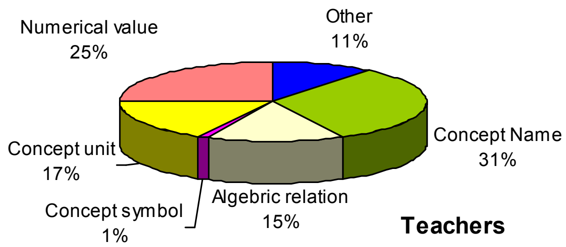


Fig 3: Comparison of the semiotic forms of concepts occurrences when concepts are used by the students or by the teachers.

The students' difficulties

In fact most difficulties encountered by the students concentrate around units. These difficulties have various origins, they occur at almost all stages of the students' work and they accumulate. This leads the students to debate and look for information. This explain (at least partly) the high level of the occurrences of the concepts all along their work.

The first main difficulty happens when the students interact with the measuring device during the experiment. It concerns the units and the meaning of these units, and therefore the meaning of the corresponding concepts and of the law linking the concepts. We count a very high value of concepts occurrences per minute for the interaction of students with the device: the students spend a short time using the device, but meanwhile concepts are particularly intensely used. One can think that this is because of measured values of physical quantities, but in fact the use of the device initiates a discussion about the physical quantities (the students use units names) to be measured. This leads the students to look for information on the web, and they encounter multiple difficulties in this activity.

The main difficulties are summarised below:

- The students have difficulties to adapt their strategy when then they are obliged to make some changes. For instance they plan to measure the energy consumed by the TV set when it is on and when it is off with sleep mode. Then it happens that the measuring device could not be used to measure energy the way they planned it. The students then turn to power measurements, but they deal with power the same way than initially planned with energy. It seems that they do not really figure out that power is not energy, and that time duration has a role to play. The relation between the two concepts is not mobilized. But probably the students do not really have a precise idea of the role played by time in their initial plan with energy.

- The students have to make links between the scientific world and the everyday life world. They have to use kW.h units and they have difficulties to understand that this is an energy unit. The energy unit they learn for the energy concept in physics is the joule. The unit kW.h is mostly used on electricity bills and electricity meters in everyday life, and probably 16 years old students are not familiar with this: the transcription reveals that they do not understand the raison d'être of such a unit. Furthermore they are mixed up between kW.h and kW/h: in everyday life French people usually pronounce "kilometer hour" for the km/h units instead of saying "kilometer per hour". Therefore kW.h sounds as kW/h at first for the students.

- The students have difficulties to interpret the meaning of the concept express from the unit: they really have to fight with the significance of kW.h and they discuss hard to understand what can be a kilowatt multiplied (or divided!) by time duration.

- The students do not mobilize their conceptual knowledge to solve a question. For instance in the discussion about kW.h, the students do not try to relate it to the $E = P * t$ relation, even if they know it (they refer to it in other circumstances). This may be due to the fact that they did not use this knowledge this way before and that they do not know much about the dimensional analysis practice.

- The students often use indifferently units names, units symbols and physical quantities symbols and sometimes numerical values. This leads them to confusion with laws in mathematical form. For instance they interpret w symbol (work) within an algebraic relation as the symbol for power unit (watt).

- Information collected freely on the web is difficult to interpret for the students. They find information but they often are not able to identify if this is the proper information or not. And they often cannot interpret the information they have selected. First the information is often abundant and varied, and thus this requires to perform a selection. Second it is most of the time not adapted to the students' conceptual knowledge level and skills: in the previous example the students encounter a concept related to energy that they do not know (work) and in this case they interpret it as power, because of the symbol confusion previously mentioned. In this case the information about work is available but they do not read it at first (they just pick an equation in a document including several pages), and when they do read the related explanation they could not understand it. This is also true when they do encounter the proper information they look for. A climax is reached when the students encounter erroneous information on the web (such as kW/h unit symbol).

In the given example, one can note that almost all the listed difficulties cumulate. This leads to a highly confusing situation, but this also leads the students to frequent discussions about the meaning of the physical quantity corresponding to kW.h and its link with power and time duration. These discussions engage them to experience spontaneously some kind of dimensional analysis. Apart from one boy, the students could not totally solve the point from these discussions, but they finally succeed when they really get engaged in the proper calculation and comparison of energy consumed by a TV set (for given durations when it is on or when it is off with sleep mode). The success in this case could not come from reflection (despite a great effort), but it comes through action.

At the end of the session, after several tries of data processing and with the teachers' guidance and assessment, the students reach the first correct result and it sounds as an answer to the problem they wanted to solve. From this point they are able to give sense to the appropriate strategy for data processing, and everything takes its place and goes the proper way as an evidence. At the end of the session, they go on totally by themselves, working for more detailed results after the end of the session, and dealing with concepts as experts could have done. Their final calculation sheet shows results with values, symbols and units organised in the most proper way.

CONCLUSIONS

Studying the way students use the concepts, it appears that the semiotic form of concepts occurrences may be interpreted as a marker of the students' conceptual mastery and of their understanding of the scientific task they perform. In this case study, the students start dealing with concepts through the experiment and this may explain the dominant and interesting role played by units names in the students' verbalizations.

The obstacles encountered by the students are multiple and difficult to predict. The free use of the web as a source of information appears to be highly problematic. The students often find information which is not adapted to their needs or which is erroneous. As novices, the students lack knowledge and skills that allow an expert to find his way even out of his domain of expertise (Schraagen, 1993). The students also need assessment to know if what they have done is pertinent, sufficient or correct. They often do not have enough ability to control and evaluate their activity and productions without help. We observe that they give up if they do not find any satisfying answer to their questions. Sometimes they go on with a task despite they know it is going a wrong way. Because the students could get enough help to pass the main obstacles, the difficulties encountered drive the group to share and question their conceptual knowledge, to argue and go deeper with the concepts, and to experience new scientific skills such as dimensional analysis. Therefore, on the point of view of the students' conceptual activity, this experience of an inquiry situation appears as rich and fruitful. This is due to a complex and fragile equilibrium between the students' motivation, their scientific skills level, the stimulation and hindrance of the encountered obstacles and the scaffolding they get from teachers. One can also guess that the fact that the students have (at the end) a clear feeling of the consistency and value of their work, has consequences.

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A TYPOLOGY OF STUDENTS' KINETIC VIEWS OF CHEMICAL EQUILIBRIUM SYSTEMS

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Abstract: Literature identifies the insufficiency of Le Châtelier's principle, and research describes a number of problems that students have in explaining and describing chemical equilibrium systems. In this study, questionnaires and interviews were used to consider the impact and extent of these issues for chemistry students in two schools. Thematic analysis through iterative coding of student responses resulted in the identification of 3 levels of explanation: A 'Holistic' level is when students describe how the behaviour of the microscopic and dynamic forward and reverse reactions affect each other resulting in system equilibrium properties; students explaining at the 'Mirrored reactions' level described the forward and reverse reactions behaviours as mirroring each other, but their combined system effect is not identified. For the remaining students, the forward and reverse reactions do not affect each other and are considered separately in explanations ('Reactions not connected' level). As many students do not offer 'Holistic' explanations, teaching strategies are suggested to enable students to develop such an understanding.

Keywords: equilibrium, particle theory, holistic thinking

BACKGROUND AND PURPOSE:

Teacher researchers identified extensive use of Le Châtelier's principle as an algorithmic device to solve problems related to chemical equilibrium processes. While Le Châtelier's principle has its uses in predicting macroscopic behaviour under certain conditions, its limitations are rarely acknowledged in schools. Solomonidou and Stavtidou (2001) identified applying Le Châtelier's principle to chemical systems before they reach equilibrium as such a limitation. The purpose of this research was to determine students' levels of understanding by probing their ability to explain such systems using particle interactions and dynamics.

As a proviso we recognise that chemists' explanations of equilibrium in chemical systems is more appropriately explained by changes in entropy but that at pre-university level the kinetic holistic understanding we have described will support such explanations when they are later introduced.

RATIONALE:

To identify strategies that can be used to enable students to explain the relationship between the microscopic and macroscopic behaviour in equilibrium system based on an iterative analysis of student explanations of such systems.

METHODS:

We designed a questionnaire in which students were asked to

a. Predict macroscopic effects in reversible chemical systems
b. Describe and explain the influence of rates of forward/reverse reactions on a system

c. Draw graphs to describe/predict the rates of forward and reverse reactions in the system.

101 students gave responses to one or more questionnaires in two different schools (A & B). To reduce bias in terms of the context of the chemical system, two papers containing exactly the same questions but referring to different contexts (see table 1) were given randomly to the students. The first questionnaires were given just after their first post-16 teaching of equilibrium which included reversible reaction systems and factors which affect equilibrium (June 2009). The second set of questionnaires was given after further teaching which considered chemical equilibrium systems in terms of K_p and K_c (November 2009) (Table 1).

Questionnaire	Chemical system(s) proving the context for the questions	Questionnaire timing (School A or B (numbers of pupils))		
		June 2009	Nov. 2009	May 2010
Q1	Ester – acid and alcohol system: $CH_3COOC_2H_{5(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + C_2H_5OH_{(aq)}$	A (25) B (21)	A (11) B (19)	
Q2	Chromate - dichromate system: $2CrO_4^{2-}{}_{(aq)} + 2H^+{}_{(aq)} \rightleftharpoons Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)}$	A (24) B (17)	A (19) B (18)	
Q3	For the same questions as Q1 & Q2 : Bismuth oxide chloride - bismuth trichloride system: $BiOCl_{(s)} + 2HCl_{(aq)} \rightleftharpoons BiCl_{3(aq)} + H_2O_{(l)}$ For additional questions: Nitrogen oxide – nitrogen oxide chloride system: $2NO_{(g)} + Cl_{2(g)} \rightleftharpoons 2NOCl_{(g)}$			A (28) B (32)

Table 1: Details of the questionnaire contexts chemical system contexts, administration timings and the numbers of pupils responding in each school

Approximately four months after the second questionnaire was administered, a sample of 13 students, were interviewed and were asked to:

a. Describe their general approach to answering chemical equilibrium problems
b. Describe the Haber process from a particle perspective
c. Account for their rates graphs drawn as responses in questionnaires 1 and 2.

All interviews were audio-recorded.

Later a third questionnaire was administered which covered the same questions as the first two using another context (see table 1) and a further two questions in a further context.

Through inductive analysis of questionnaire responses four researchers derived a coding system which was iteratively refined to identify three general levels of understanding of equilibrium systems. Interview responses were used to cross-check for consistency with responses from the questionnaires. We will use case studies to illustrate the nature of each of these types of understanding.

CASE STUDIES:

Holistic Understanding:

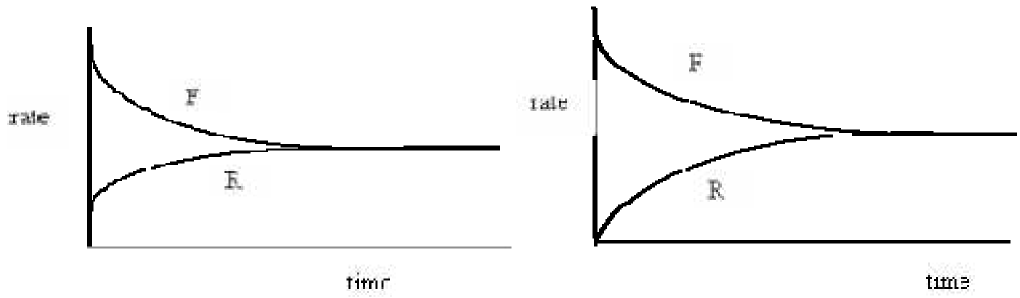
The forward and reverse reactions are described as affecting each other which results in the system equilibrium properties.

Ben (a pseudonym) is a high achieving student. He enjoys developing his thinking about the more challenging concepts.

His approach to equilibrium problems is to use mathematical relationships between the equilibrium constant and rate expressions. He describes his visualisation of a reversible chemical system in terms of colliding particles with the forward and reverse reaction occurring simultaneously. He uses Le Châtelier's principle alongside other approaches. He provided very detailed answers in all questionnaires and to interview questions. For example, Ben described the change in the rate of the forward reaction on the last questionnaire:

> *'As they react, their concentration will decrease due to dilution from the now formed products…the rate of reaction will decrease until dynamic equilibrium is reached…the rate of reaction will reach a constant value.'*

When asked to graphically represent changes in the rates of forward and reverse reaction he drew the graphs in Fig. 1 on his first two questionnaires (on the third questionnaire he drew one with the same key features as that for the second questionnaire).



Q1 Q2

Fig. 1: Ben's graphical responses in questionnaires Q1 and Q2 (F- forward reaction and R- reverse reaction lines).

Ben accounted for the difference between these two graphs in his interview by describing his first graph:

> *'To start with ….there is none of other one to react [product], so I should have really started that one [points to reverse reaction line] at zero then…..As they react the concentration of them [points to forward reaction line] goes down … and the concentration of them [points to reverse reaction line] goes up. So the rate of reaction, so less of it to collide … the rate of it [forward reaction] goes down and the rate of the other goes up for the same reason. After a while we reach equilibrium which means of course that the rates must be equal for each of them.'*

Mirrored reactions understanding:

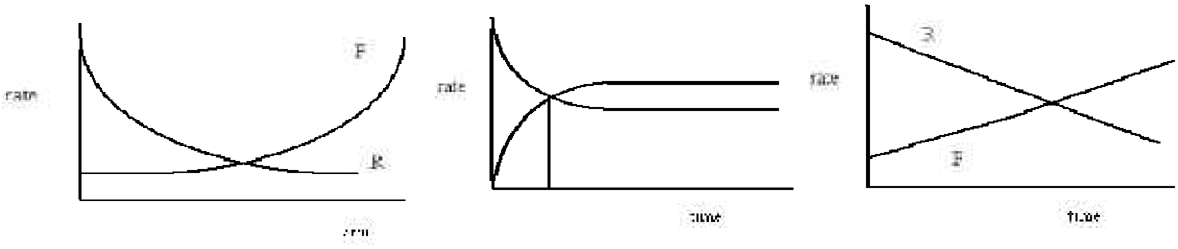
The forward and reverse reactions mirror each other, but their combined system effect is not identified.

Martin (also a pseudonym) attains middle grades in chemistry, which is the only science subject he took. He finds science subjects more challenging.

Martin’s approach to equilibrium problems is to use Le Châtelier’s principle. He describes his visualisation of a reversible chemical system in terms of colliding particles focusing on the forward reaction. For example, Martin described the change in the rate of the forward reaction on the second questionnaire:

> *‘The rate of these will decrease and increase until the rate of the forward reaction and the rate of reverse will be equal and then the equilibrium has reached a dynamic equilibrium.’*

When asked to graphically represent changes in the rates of forward and reverse reaction he drew the graphs on his questionnaires (Fig. 2):



Q1 Q2 Q3

Fig. 2: Martin’s graphical responses in questionnaires Q1, Q2 and Q3 (F- forward reaction and R- reverse reaction lines where indicated).

Martin accounted for the shape of his first two graphs in his interview:

> *‘As water is added you get more and more of the product… You finally reach a point of a dynamic equilibrium, where the rate of forward reaction and rate of reverse reaction are completely equal. …… reactants are reacting considerably more because the rate of the forward reaction is much greater…… When lines hit on this one [graph Q2] is point of dynamic equilibrium…’*

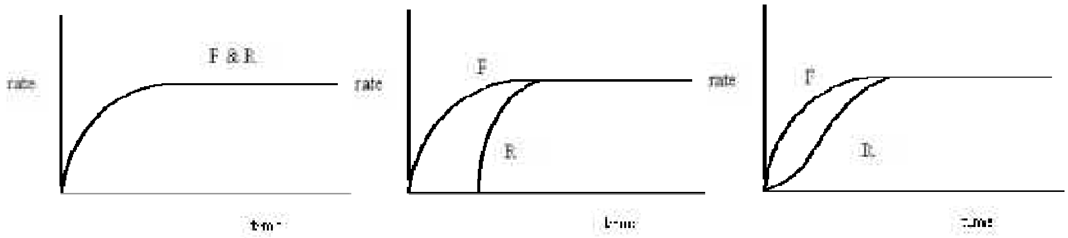
Reactions not connected understanding:

The forward and reverse reactions do not affect each other and are considered separately.

Here we consider Anna’s (pseudonym) responses to describe the features of this sort of understanding. Anna achieves A and B grades and likes chemistry, which she needs to study as a prerequisite to study Medicine. Her approach to equilibrium problems is to apply Le Châtelier’s principle. She identifies key knowledge and draws on algorithms. When visualising a reversible chemical system she notes the bonds that are broken or made in the forward reaction before considering those in the reverse reaction in a stepwise fashion. Her use of key knowledge is illustrated in her response when asked to describe the change in the rate of the forward reaction on the second questionnaire:

> *‘At equilibrium the rate of reaction is constant.’*

When asked to graphically represent changes in the rates of forward and reverse reaction Anna drew the graphs shown in Figure 3 on her questionnaires:



Q1 Q2 Q3

Fig. 3: Anna's graphical responses in questionnaires Q, Q2 and Q3 (F- forward reaction and R- reverse reaction lines).

Anna accounted for the shape of her first two graphs in her interview:

> *'I knew [forward reaction]….. the concentration would decrease and then level out. So the rate of reaction would increase and level out... It obviously has to start at zero because nothing is happening then it's got to increase to the point it would be at dynamic equilibrium…..[reverse reaction] has to start at zero as well and it also has to level out because when it is in dynamic equilibrium, the rate of reaction is constant. And the whole point of dynamic equilibrium is the rates of reaction are the same…… They have to be on the same line, because they have to be the same value.*

When asked about the difference between Q1 and Q2 graph Anna responded:

> *'The first reaction is happening… It's not quite produced enough of the product, so you have to wait a bit of time for the [reverse] reaction to start happening...'*

FINDINGS:

Twenty-three of all students (57) completing the final questionnaire (Q3) responded in a manner consistent with 'Holistic' thinking. Twenty-one of these 57 students provided explanations that indicated thinking about the forward and reverse reactions as 'Mirrored reactions' and the remaining students (13) did not show that they were connecting forward and reverse reactions in their responses (Fig. 4).

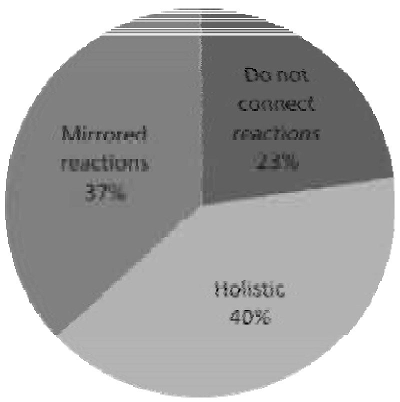


Fig. 4: The distribution of types of understanding of reversible chemical systems identified from the final questionnaire responses.

CONCLUSIONS AND IMPLICATIONS:

There was evidence that at the end of their equilibrium course 40% of students were able to view the chemical system holistically, when they can account for variations in rates of reaction using either/or mathematical relationships or particle interactions . These students will be able to explain equilibrium phenomena beyond the limitations associated with a reliance on Le Châtelier's principle. The other 60% of students, however, will experience difficulties in doing so.

Given that 22% of students demonstrated holistic understanding after initial teaching and that then only a further 19% of students were able to develop this understanding with further teaching, which is modelling chemical equilibrium systems via mathematical means, suggests that they do not have sufficient representational resources to flexibly manipulate aspects of the chemical equilibrium system (Raviolo and Garritz, 2009). It is clear that students need further support in modelling chemical systems which explicitly interconnect the macroscopic with the microscopic or particle interactions (Maia and Justi, 2009). Such an approach would include these stages:

a. The fundamental view of particle theory that the macroscopic behaviour of systems can be accounted for by particle behaviours;
b. Dynamic particle models, for example, role play or computer simulations (for example, PhET Interactive Simulations (2010)), where students note the changes in the rates of the forward and reverse reactions alongside the macroscopic effects.
c. Encouraging students to explain changes in chemical systems in terms of dynamic particle interactions.

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STUDENTS' SENSE-MAKING OF ELECTROMAGNETIC INDUCTION: A SEMIOTIC ANALYSIS

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Abstract: Visualization plays an important role in the conceptualization of electromagnetic induction. The ability to visualize what goes on in an electromagnetic induction phenomenon using culturally consistent semiotic resources is a crucial determinant to successful problem solving. Understanding how students make sense of electromagnetic induction phenomenon with semiotic resources should thus be an important aspect in studies of students' conception of electromagnetic induction. In this paper, I propose the use of social semiotics as a lens to understanding students' conception of electromagnetic induction. In particular, the framework of systemic functional linguistics is applied to multimodal texts to study two students' meaning-making of a problem on electromagnetic induction and hence their conception of electromagnetic induction. It was found that while the two students solved the problem successfully, their sense-making of the phenomenon with semiotic resources was different. The choice and use of semiotic resources was indicative of how they conceived the idea of electromagnetic induction. It is thus concluded that a semiotic analysis framework is useful to understand students' conception of EMI.

Keywords: scientific visualization, electromagnetic induction, social semiotics

INTRODUCTION

Electromagnetic induction (EMI) makes extensive use of visual imagery to theorize the production of current when a conductor experiences a change in magnetic field (Rieber, 1995). In a similar vein, students need to appropriate these visual tools in thinking and exploring the phenomenon of EMI. Students' ability to use these culturally-consistent tools in making sense of EMI should thus be one key factor when considering students' conceptualization of the topic.

While there have been extensive studies done on students' conceptions of EMI (e.g., Maloney, O'Kuma, Hieggelke, and Heuvelen (2001), Saglam and Millar (2006)) which have produced a comprehensive list of content-specific difficulties that students have with EMI, it may not inform any specific competencies in the use of representations that students need in making sense of EMI phenomenon. Yet, visualization studies in science education mostly focus on measuring students' visual-spatial capability using instruments adapted from educational psychology (e.g., Purdue visualization and rotation test (Bodner & Guay, 1997)). These tools, based on cognitive theory, may not provide much useful information about students' ability to recognize cultural-specific visual tools, use them to communicate information or apply them to solve problems. An alternative perspective based on social semiotics theories may provide illuminating insights instead. However, such studies on scientific visualization are few. The goal of this paper is thus to propose an analysis framework based on social semiotics to study students' visualization of EMI and to use it to understand students' conception of EMI. The research question that I ask is "what meanings of EMI were made by students using semiotic tools?"

THEORETICAL FRAMEWORK

Social semiotics is a branch of study that perceives signs and symbols to be imbued with a meaning by community/context which in turn shapes the context in which these representations are used (Halliday & Hasan, 1985). Scientific visualization can thus be conceived as symbols or signs constructed or transformed and used by scientists as material and social tools in understanding and developing the scientific field. For example, lines of force, drawn to represent intensity and strength of a magnetic field, have been used as materials tools for scientists to think about its interaction with electrons and served as communication tools to support social discourse among scientists about EMI. These signs and symbols made up of language, gestures, iconic figures could express different levels of representations: macro (physical objects), micro (inferred "objects") or symbolic (symbols and equations) (Gilbert, 2007). They form a cultural-specific semiotic system that characterizes the scientific community through which scientific meanings are construed.

Based on the framework of systemic functional linguistics (Halliday & Hasan, 1985), different forms of meaning can be construed with semiotic resources (Lemke, 1998). The selection, usage and combination of these resources can provide information about the events and relations one makes (*presentational* meaning), the attitude one has towards the content and others (orientational meaning) and the degree of coherence of the text (*organizational* meaning). Table 1 summarizes how the three metafunctions of semiotic resources can guide the analysis of students' meaning-making of scientific phenomenon with semiotic tools.

Table 1: Description of three metafunctions of semiotic resources

Presentational	*Orientational*	*Organizational*
Identifies kinds of relations construed among semiotic resources in terms of events and relationships (e.g., Φ = BA indicates identifying relations)	Identifies the kinds of semiotic resources used in meaning-making (e.g., symbols and graphics) and level of representation	Identifies how semiotic resources are organized (e.g, figure of a coil and pictorial lines of force show the spatial arrangement of Φ, B and A

METHOD

This section reports the sense-making of EMI by two Grade 12 students, Peter and Nancy, chosen at random, during a think-aloud protocol interview. This interview was conducted after lectures on EMI were completed. Instruction on EMI includes demonstration of EMI experiments and visual-rich graphics to explain the concept of EMI at the macro (physical objects), micro (effects on electrons) and symbolic (formulas) levels of representation. During the interview, the students were encouraged to draw, write, say or use objects as representations to explain their solution. The interview was video-recorded to capture the use of semiotics during problem-solving, transcribed and analyzed according to the framework shown in Table 1. The problem given is shown in Figure 1.

Problem:

A copper disc spins freely between the poles of an unconnected electromagnet as shown in the figure on the right.

Describe and explain what will happen to the speed of the rotation of the disc when a direct current is switched on in the electromagnet.

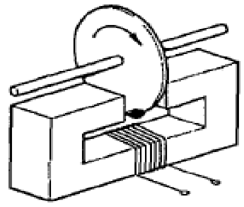


Figure 1. Problem of an EMI phenomenon

STUDENTS' MEANING-MAKING OF ELECTROMAGNETIC INDUCTION PHENOMENON

The two students predicted correctly that the copper disc would slow down when a current flowed in the solenoid. However, they made sense of the phenomenon differently. Figures 2 and 3 show excerpts of their explanations given by the two students, Peter and Nancy.

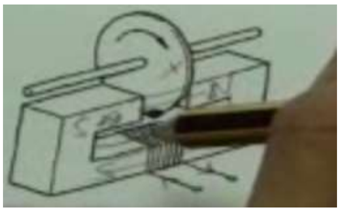
(i)

… this is a particular *point* before it was subjected to this magnetic field lines …

(ii)

Same situation when the magnet is try to enter a coil … Before you try to enter … this *copper disc* … will try to oppose the change …

(iii)



… it's the same as the pulling the magnet out of the coil … will like induce another e.m.f. … attract *this point* back to the magnetic field.

Figure 2. Peter's meaning-making of EMI phenomenon

Using drawings and gestures as representations of specific and observable objects and processes of the phenomenon (refer to Figure 2), Peter identified "a particular point" on the disc (by pointing out a specific physical point on copper disc as in (i)) to be in the "same situation when the magnet is try to enter a coil" (as he used his fingers to curl like a coil of wires in (ii)). Drawing parallel to a magnet pulling out of a coil, he concluded that the copper disc "will … induce another e.m.f". Although Peter was able to predict correctly the effect on copper disc, he was merely drawing associative relations to an event he had encountered, drawing upon concrete objects and processes in his sense-making of the phenomenon rather than culturally-specific representations.

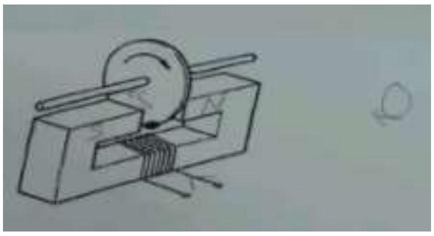
(i)		I think about the *particle* inside this rotating disc … the *electrons* … into the page …
(ii)		so there is a *current* is going out of the page… so there will be *force going downwards*.
(iii)		Current is induced by the *movement of electrons*. … it's (disc) slow down … because of *current flowing upwards* …
(iv)		then there will be *force going out of the page* … so it will be slowing down.

Figure 3. Nancy's meaning-making of EMI phenomenon

Nancy, on the other hand, made different types of meaning of the phenomenon and at different levels of representation (refer to Figure 3) compared to Peter. Although the modes of representations (i.e., graphics and gestures) were similar, Peter's diagrams and gestures were representatives of physical objects/parts in the experimental set-up in the problem (macro level) while Nancy used pictorial representation of an electron (refer to enlarged dot in (i)) and gesture (Fleming's left hand rule) to indicate relationship between direction of forces, current and magnetic field in Figures 3(ii) and (iii)). With these semiotic resources, Nancy drew consequential relations about the direction of current flow as she considered the motion of the enlarged dot drawn, and causal relations as she deduced the subsequent motion of the electron resulting from its motion in a magnetic field using Fleming's left hand rule. Here, drawings, hand gestures and language have mediated Nancy's construction of the invisible events happening to equally microscopic objects. Unlike Peter's meaning-making of the phenomenon, Nancy's involved imageries consistent to those of EMI.

DISCUSSION AND CONCLUSION

Science is not constructed on verbal language alone (Lemke, 1998). The ability to visualize what goes on in an EMI phenomenon with culturally consistent multi-modal resources is an important determinant to successful problem-solving. The analysis framework proposed in this paper helps to illuminate the differences in meaning-making between two students, albeit predicting the outcome of the phenomenon correctly. The study on the kinds of semiotic resources used by the students by drawing inferences to the kinds of meaning made, the levels of representations and coherence of their sense-making was able to provide evidence about students' conceptual understanding of the EMI. It is obvious that Nancy's fluency in transiting between macro and micro levels of representations using different kinds of semiotic resources as she considered the effect on a moving electron in a copper disc (micro) as the copper disc rotated (macro) was more consistent with the kinds of cultural-specific tools used to think about EMI phenomena. Gilbert (2007) describes this fluency in visualization involving the ability to acquire, monitor, integrate and extend learning from representations as metavisualization. Peter's visualization, on the other hand, was mainly that of associative relations as he focused on macro representations (a point on copper disc indicated by pictoral symbols) in his visualization and making association with equally concrete experiences he had come across. Such meaning-making pattern tends to be less generalizable to other situations and may be an indication of possible difficulties with the use of representations consistent with the field of study. The difference in the levels and types of representations used by the two students – Nancy shifting between macro and micro levels using cultural-specific representations while Peter relying mainly on macro objects and events – during problem solving could perhaps point to another source of difficulty students might have with EMI, thus extending the comprehensive list of conceptual difficulties students have with content-specific concepts already established. Thus, a social semiotic analysis could thus be useful in identifying a student's competency in using the appropriate levels of representation in his/her sense-making of an EMI phenomenon.

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CAUSAL RELATIONAL REASONING OF 5TH GRADERS USING DENSITY IN EXPLAINING FLOATING-SINKING PHENOMENA

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Abstract: The aim of the present study was to investigate if students use causal relational reasoning using density in explaining floating/sinking (F/S) phenomena before, during and after the implementation of a Teaching/Learning Sequence (TLS). The study is part of a cross-national research-based curriculum project on Materials Science. One of the theoretical bases for the design of the TLS was focused on a model-based learning approach. The TLS was designed and developed by researchers working in close collaboration with school teachers comprising a University – School partnership. Its implementation took place in two science classrooms of forty-one 5th graders (mean age 10.9; *SD* =.376) in total. Participants answered 5 tasks (pre, during, just after and seven months after the implementation) on explaining F/S phenomena using the concept of density. A significant shift on participants' conceptual understanding was evident; participants grasped the scientific concept of density after the intervention. In addition, it seems that a significant number of participants could successfully explain F/S, using causal relational reasoning. Finally, participants who managed to use density in a causal relational reasoning had a significantly better understanding of density as a property of materials than those who used density in a causal linear reasoning.

Keywords: Model-based learning, Causal relational reasoning, Concept acquisition, Density, Floating/Sinking phenomena

BACKGROUND, FRAMEWORK, AND PURPOSE

Model-based reasoning can be thought of as a continuum in which teachers begin with students' basic representational capacities and try to end up near the practices of scientists (Nersessian, 2008). An important constrain in this transition is the narrow range of students' causal models. Most of them tend towards simple causal models in explaining phenomena. For instance, when they try to explain F/S of an object, they focus only on the object, giving answers such as "it sinks because it is heavy" (Kohn, 1993). However, many concepts and theories in science depend on substantially more complex causal models (Perkins & Grotzer, 2005). Causal relational reasoning, being such a complex model, in the case of F/S provides interpretations such as "if an object has bigger density than a liquid then it sinks". Perkins & Grotzer (2005) argued that cultivating greater complexity in students' causal models leads to better understanding of phenomena and relevant concepts that are used to interpret them.

Moreover, there is a considerable agreement that density is an abstruse notion for students. Students, before being exposed to the systematic teaching at schools, have already developed a conceptual framework about matter and material kind, which differs from the scientific one (Smith, Snir & Grosslight 1992; Hardy et al. 2006; Wiser & Smith 2008). Within students' conceptual framework, the concepts of weight and density are undistinguished

(Fassoulopoulos, Kariotoglou & Koumaras, 2003). Moreover, students by referring to the density of an object, they focus on only one feature of the object, either on the weight, the size or the shape, (Smith, Snir & Grosslight, 1992). Smith et al. (1992) also argued that the necessary condition to conclude that students have grasped the concept of density, in an elementary level, is to realize that the heaviness of the kind of material is a property of that material. In addition, they claim that this is a prerequisite in order to argue that students can distinguish the concepts of weight and density.

RATIONALE

Although the concept of density is considered among the most difficult concepts for primary school students, there is little empirical evidence of (TLSs) (Méheut & Psillos 2004), that use the model-based reasoning to help students to abandon the constraints of the linear causal reasoning (Perkins & Grotzer, 2005). In this study, we were keen to answer the following research questions: (a) In what extent do students acquire density as a property of materials? (b) Do students use causal relational reasoning in explaining F/S? (c) Does the use of complex causal reasoning help students to understand the concept of density? For this purpose a five unit TLS on density as a materials property (Spyrtou, Zoupidis & Kariotoglou, 2008) has been developed.

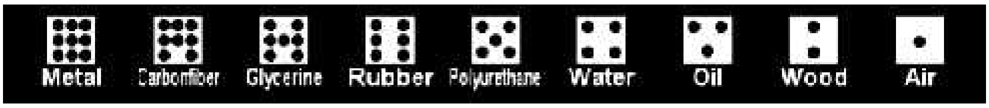

Fig. 1: The visual "*dots-in-a-box"* model of several materials

More specifically, in the 1st unit of the TLS, participants were introduced to the technological problem of the salvage of the *Sea Diamond*'s shipwreck through a video which included a description of the accident and a discussion about its environmental consequences. Furthermore, the participants were familiarized with F/S phenomena and the relevant concepts through several activities, such as real experiments, working in a Predict-Observe-Explore (POE) approach. In the 2nd unit, the participants working in groups, followed the POE approach in real and simulated experiments in order to identify and test possible variables that affect F/S, for instance, the weight of an object and the kind of the liquid's or the object's material. In the 3rd unit the participants were introduced to a visual model of density as a property of material, the "dots-in-a-box" model (Smith, et al., 1992, Figure 1). Using this representation in relevant simulated experiments we expected that the participants would acquire a causal relational reasoning (Perkins & Grotzer, 2005) in order to explain and predict F/S phenomena for homogenous objects. In the 4th unit, participants used the visual model to come to a conclusion about the F/S of two-materials composite objects, for instance a bottle filled with air or a bottle filled with water. By doing this, we aimed to help participants to understand that the density of a composite object, which consists of two materials, lies between the densities of the two materials. Finally, in the 5th unit, participants had the opportunity to work in groups in a simulated environment and to investigate the F/S of the *Sea Diamond* cruise ship, in order to argue about its salvage.

METHOD

This study was conducted in two 5th grade science classrooms. Forty one 5th graders (mean age 10.9, *SD* =.38) participated in the study. Each of the five units of the TLS lasted for 2 teaching periods of approximately 80 min in total. The implementation took place during normal daily courses and the female class teacher had great experience in teaching science.

Data Collection: Data were collected from multiple sources. For the sake of conciseness, in this paper we will be limited in presenting the results only of the analysis of the learning of density as a property of materials (Tasks 1, 2 and 3), as well as the use of causal relational reasoning in explaining F/S (Tasks 4 and 5) of the pre (just before implementation), interim (between 4th and 5th unit), post (just after implementation) and post-post (seven months after implementation) phases of evaluation. More specifically, task 1 asked participants to write a sentence including the words density and material. Task 2 asked participants to choose and explain their choice, on which of two objects of the same amount and material, but of different shape has bigger density, or if they have the same density. Task 3 asked participants to choose and explain their choice, on which of two objects of the same material, but of different size has bigger density, or if they have the same density. In task 4 participants were asked to draw a big sphere and a small triangle in their final position in a liquid, taking into account the densities that are given in “dots-in-a-box” representation (sphere’s material: two dots, triangle’s material: six dots and liquid’s material: four dots). They were also asked to explain their drawings. Finally, in task 5, participants were asked to choose and explain their choice, about the final position of two identical spheres in a liquid, taking into account the densities that are given in “dots-in-a-box” representation (object’s A material: two dots, object’s B material: three dots and liquid’s material: four dots). The first choice was that the two objects are floating at the same level, the second that object B floats in a higher level than object A and the third choice is that object A floats in a higher level than object B. Tasks 1, 2 and 3 were addressed to participants in each of the four phases (pre, interim, post and post-post) of the TLS, while tasks 4 and 5, only in the last three phases.

Coding: Answers in tasks 1, 2 and 3 were classified in four categories, and in tasks 4 and 5 in two categories, by two independent judges, with 85% agreement which after a discussion was increased to 100%. The same categories were used in the tasks 1, 2, and 3. Phenomenological, incomplete or no answers were classified in the “no answer” category (0). Answers that accepted density as dependent on the object’s size, (e.g. “the big object has bigger density”), were classified in the category “extensive idea” and they were credited with one (1). Answers that accepted density as a property of materials and dependent on the object’s size, (e.g. “the objects have the same density because they are made from the same material and the same quantity”), were classified in the category “transitional idea” and they were credited with two (2). Finally, answers that considered density as a property of materials, (e.g. “both objects have the same density because they are from the same material”), were classified in the category “intensive idea” and they were credited with three (3). The means of the classification in these three tasks were calculated and rounded for each student.

Answers that were based on causal relational reasoning to explain F/S, (e.g. “object A floats because its density is smaller than the liquid’s and object B sinks because its density is higher than the liquid’s”), in task 4, were classified as “causal relational” and credited with one (1). Additionally, answers that used causal linear reasoning, “(e.g. object A will float because it is light and object B will sink because it is heavy”), were classified as “causal linear” and were credited with zero (0). Answers that used causal linear reasoning in task 5, (e.g. “they both float because they are light”), were classified as “causal linear” and were credited with zero (0). Additionally, answers that used causal relational reasoning to explain F/S, (e.g. “I choose the third picture because both objects have smaller density than the liquid and object B has bigger density than object A”), in task 5, were classified as “causal relational” and were credited with one (1). The means of the categorization in the last two tasks were also calculated and rounded for each student.

RESULTS

Table 1 presents the participants' progress in understanding the concept of density as a property of materials. As it was expected, the number of participants that considered density as a property of materials increased significantly after the first and second part of our implementation (interim and post measure), while the number of participants answering irrelevant, phenomenological or incomplete answers decreased significantly from the pre to the post phase of evaluation (Wilcoxon Signed-Rank Test, z=4.8, p <.001). Furthermore, the pattern of answers remained unchanged from post to post-post evaluation (Wilcoxon Signed-Rank Test, z=.29, p =.770). Nevertheless, a small though considerable number of participants were still assuming that density is an extensive quantity (category 1).

Table1. Frequencies of participants found in each category in each time-point concerning learning of density as a property of materials

Tasks 1, 2 and 3	**Time-points**			
Categories	**pre**	**interim**	**post**	**post-post**
3: Density as a property of materials (intensive idea)	0	10	13	11
2: Density as a property of materials and dependent on the shape, weight or size of the object (transitional idea)	1	7	4	7
1: Density dependent on the shape, weight or size of the object (extensive idea)	8	13	17	15
0: Phenomenological, incomplete or no answers	32	11	7	8
Total answers	41	41	41	41

The results concerning participants' explanations of F/S phenomena are shown in table 2. These results are based on participants' answers in Task 4 and 5, which were conducted only in interim, post and post-post phase of evaluation.

Table2. Frequencies of participants found in each category in each time-point concerning participants explanations of F/S phenomena

Tasks 4 and 5	**Time-points**		
Categories	**interim**	**post**	**post-post**
1: Use of density in a "causal relational" reasoning	17	22	15
0: Use of density in a "causal linear" reasoning	24	19	26
Total	41	41	41

A considerable number of participants (seventeen out of forty-one) were able to use density in a causal relational reasoning after the first phase of our implementation in the intermediate phase of evaluation (see Table 2). This number was significantly increased in the end of the TLS where almost one out of two participants used density in a causal relational reasoning (Wilcoxon Signed-Rank Test, $z=2.7, p <.05$). However, this improvement lost at the post-post time point, seven months later, and participants started using density in a linear reasoning again (Wilcoxon Signed-Rank Test, $z=2.4, p <.05$).

Mann-Whitney non-parametric analysis was used in order to test our hypothesis that cultivating causal relational reasoning in explaining F/S phenomena could lead to better understanding of density as a property of materials. More specifically, we divided our participants in two groups; those who in each time-point understood and used causal relational reasoning and those that used causal linear reasoning in explaining F/S. For each group of participants we calculated the means corresponding to their conceptual understanding of density as a property of materials. As we expected, significantly more participants who used causal relational reasoning, understood density as a property of materials, than participants who used causal linear reasoning in interim ($p =.040$), post ($p =.007$), and post-post ($p =.001$) phase of testing.

CONCLUSIONS

The results showed statistically significant increase of the participants who understood density as a property of materials, which remained stable seven months later (Table 1). Furthermore, there were a considerable number of participants who used density in a causal relational reasoning to explain F/S phenomena (Table 2). In parallel, the number of participants who used causal relational explanations in the post phase of evaluation significantly increased, in comparison with the interim one. One possible explanation for this improvement could be the use of the *Sea Diamond's* cruise ship simulation, in the 5^{th} unit. In this unit participants used the *Sea Diamond* cruise ship simulation in order to investigate the conditions under which a ship sinks and floats, in the frame of the technological problem solving of the salvage of the sunken ship. Nevertheless, this improvement did not remain seven months later. An explanation of that could be the short period given to such activities, that is, only a part of the last unit of the TLS. Last but not least, we noticed that participants who managed to use density in a causal relational reasoning had a better understanding of density as a property of materials, in a statistically significant degree, than those who used density in a causal linear reasoning. We consider that this result is in favor of Perkins & Grotzer (2005) claim, that cultivating complex causal reasoning can enhance participants' concepts' understanding.

ACKNOWLEDGMENT

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PART 2: LEARNING SCIENCE - COGNITIVE, AFFECTIVE, AND SOCIAL FACTORS

Co-editors: Silvia Caravita and Albert Zeyer

Cognitive, affective, and social dimensions in learning science. Design of in-school and extra-school learning environments and study of teaching/learning processes. Representational languages and knowledge organization. Collaborative construction of knowledge.

This part corresponds to strand 2. It contains 27 papers.

TABLE OF CONTENTS OF PART 2

LEARNING SCIENCE - COGNITIVE, AFFECTIVE, AND SOCIAL FACTORS

SCIENCE TEACHER TRAINING THROUGH AN IBL EXPERIENCE

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Abstract: Educational research has revealed that inquiry-based learning (IBL) methodologies facilitate science understanding and the development of scientific competences, offering strategies to overcome academic failure and to ensure students' scientific literacy. A review of the Spanish projects with a focus on science education carried out in the last twenty years, shows very few initiatives explicitly based on the application of IBL approaches, pointing out a potential way to improve science learning. In the present paper, we describe a work aimed at promoting IBL methodologies among teachers. The main purpose is to make prospective teachers aware of the benefits associated with this kind of pedagogies, through offering them the opportunity to live an IBL experience and to reflect from practice.

Keywords: Science education, science learning, scientific process skills, IBL, teacher training.

INTRODUCTION: BACKGROUND, RATIONALE AND PURPOSE

The implementation of the "Lisbon Strategy" and the subsequent "Education and Training 2010 work program" are causing many changes in most of the European educational systems. The report "Educational system and human capital" published by the Spanish Economic and Social Council (1) in 2009, claims that "the high percentage of students' failure is connected with internal factors like the use of teaching methodologies with few practical applications of knowledge and the limited pedagogical training of teachers...". As a consequence, experts have suggested that a reflection about current pedagogical models, which are mainly based on lecturing and involve very little knowledge transfer, should be made, prompting the evolution towards new teaching methods.

IBL in Science Education

The current educational research along with the publication of several national reports, reveal the necessity to look for new approaches to science and mathematical education. There is a great deal of evidence showing not only a lack of students' motivation towards science and mathematics (Rocard, 2007), but also that science learning often becomes a "transitory experience with little application to future thought and action" in students' lives (National Research Council, 2000: 121).

With respect to the learning of mathematical and scientific knowledge, it is usually obstructed by inadequate students' preconceptions about natural phenomena, by the lack of significant instructional contexts to promote situated and transferable learning and by the abstract nature of many scientific theories and models (Ariza and Quesada, 2010). As a consequence of this disparity between students' prior ideas and theories, research has repeatedly shown that students learn normative knowledge in a superficial way, just to face or deal with school activities and exams. However, they are unable to apply scientific theories to explain real world phenomena, and their preconceptions persist after years of instruction (Franco and Taber, 2008; Taber, 2002).

Meaningful acquisition of scientific theories is promoted through active, collaborative, and inquiry-based learning (IBL), in authentic contexts. According to the National Research Council (2000), inquiry-based teaching may be understood as the experiences that help students acquire concepts of science, skills and abilities of scientific inquiry, and understanding about scientific inquiry. The American National Science Education Standards describe inquiry in education as “a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in the light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations and predictions; and communicating results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations”. (p. 23)

IBL in the Spanish context

In Spain, there is great deal of didactic projects to improve mathematics and science learning. An analysis of the theoretical backgrounds underlying these projects shows a predominance of constructivist claims. Nevertheless, though not explicitly embraced, the IBL paradigm is somehow present in some of the pedagogical features guiding these approaches. One of the very few initiatives explicitly mentioning the use of Problem Based Learning (PBL) and IBL, is that carried out by Bárcena and Ibáñez (2) (1991-2001) or by Sierra in 2004 (3). However, it must be said that although these projects led to interesting learning experiences or resulted in valuable pedagogical materials, they might be considered as isolated initiatives carried out in a limited time spam, with no continuity, or with none or very little impact on the national context.

IBL for teacher education

Research on effective learning and learning environments has proved that IBL methodological approaches foster inquiring minds and scientific attitudes in students. However, although inquiry promotes deeper science and mathematics understanding teachers may find obstacles planning and applying this methodology successfully (Olson and Loucks-Horsley, 2000). Furthermore, in Spain, there is a lack of explicit training on IBL methodologies in teacher initial education, both for primary and secondary schools. Thus, for in service teachers the implementation of inquiry learning in classrooms entails a number of significant challenges. Teacher education institutions are expected to provide opportunities for teachers to develop not only knowledge and skills as future educators, but also a good and a deep understanding of learning processes and approaches to create better learning environments for their students.

In this paper, we describe a work on science teacher training carried out using an IBL experience, designed and developed under the PRIMAS (4) framework.

Purpose

Taking into consideration the aforementioned, the objectives underlying our pedagogical approach are:

- Promoting positive attitudes towards science and mathematics learning.
- Developing inquiry skills in students, making them lifelong learners and inquirers.
- Increasing students’ engagement in their own learning process, (active and more autonomous learning).
- Making sense of scientific ideas and mathematical tools and showing their value to understand and explain the world.

- Helping prospective teachers to recognize the pedagogical value of IBL approaches, experiencing them as students and reflecting from practice.

Therefore, the purpose of our pedagogical approach is twofold: on one hand, to offer a challenging problem or situation which students (undergraduate primary school teachers) have to tackle and solve. In order to do so, they will have to develop and apply inquiry skills and make sense of science and mathematics concepts. On the other hand, since the intervention is implemented in initial teacher training, we intend to make prospective teachers aware of the pedagogical value of IBL activities, while experiencing them as students.

METHODOLOGY

The pedagogical approach being described has been implemented for four academic years (2007-2011) in an undergraduate science education course for prospective primary school teachers (teacher initial education).

Over 600 hundred undergraduates (20-22 years old) have gone through this instructional intervention, making it possible to refine it after any implementation cycle. The work has been developed within a FP7 European project aimed at promoting IBL in Mathematics and Science Education across Europe and the full activity may be downloaded from the project website (5).

The classroom activity involves three sessions (2 hours each), although the timing may vary slightly from one group to other.

Session 1

The first session involves three main objectives:

- Introduce the activity to students in a motivating and engaging way
- Encourage students to work in teams, discuss, design and plan their group work
- Supervise the experimental design made by each group of students, and offer some feedback or guidance about it.

The main purpose of the experiments proposed by students is to gather evidence and to provide foundation for their decision-making when dealing with the initial problem. Thus, an appropriate experimental design should offer answers to key guiding questions and takes into account the control of variables, making it possible to draw interesting conclusions afterwards.

At the end of the first session, teachers supervise the experimental design made by each group. Teachers should use challenging and guiding questions as a valuable instrument to promote students reflection on the appropriateness of their experiment. The main idea is to offer the minimum help to allow autonomy and self-regulation but at the same time, to avoid frustration or the promotion of non profitable ways of working.

Session 2

In the second session, students will carry out the experiments they have previously designed to test their initial hypothesis. In order to do so they will have to:

- Establish experimental conditions and differentiate between dependent and independent variables
- Make measures and acquire data
- Handle lab tools and equipments and get familiar with their appropriate use
- Decide upon the best way to organise and represent data.
- Analyze results
- Draw conclusions based on the available evidence

Session 3

The third session involves three objectives:

- Making students familiar with the production of a scientific report
- Promoting communication skills through the performance of oral presentations
- Encouraging discussion and debate on experimental results

Students must make a report including all the relevant information associated with their investigation and present their report to the rest of the class. The scientific report should include the following sessions: title, authors, abstract, keywords, introduction, methodology, results, conclusions and references.

Students may use specific software to assist them in the presentation and discussion of their work. After any of the presentations, teachers must encourage students to criticize and discuss their mates' work in a constructive way.

RESULTS

The implementation of the instructional intervention has promoted a high level of students' participation and engagement. Although it has always been offered as optional, over 80% of students took part in it, offering positive feedback about the experience.

The IBL activity offers an appropriate context to develop inquiry skills associated with the following processes: definition and simplification of complex problems, formulation of hypothesis, design and performance of experiments, control of variables, use of lab tools and equipment, making systematic observation, measuring, quantifying, representing experimental data, establishing relationships and connections among variables and phenomena based on the available evidence, inferring, making a scientific report and discussing and communicating results.

Additionally, it presents a situation where several science and mathematics concepts and procedures may be applied in a meaningful way (hydration, osmosis, health, differentiation and identification of variables, continuous magnitudes such as mass, volume and capacity, measurement of continuous magnitudes, equivalent magnitudes, units and values, additive and subtractive comparisons, data handling and representation and modelling of dynamic systems).

FINAL CONSIDERATION AND FUTURE IMPLICATIONS

National reports highlight the need to promote the use of new pedagogies to improve science and mathematic learning. In this setting, special attention should be paid to teacher education and teacher professional development, since teachers are the key players in educational reforms.

Research on effective learning and learning environments shows the positive effect of IBL on students' motivation, on the development of inquiry skills and on the promotion of conceptual understanding (Minner *et al*, 2010). Therefore, a classroom in which students use scientific inquiry to learn is one that resembles those that research has found the most effective for learning for understanding (National Research Council, 2000). However, an analysis of the Spanish context shows that IBL methodologies are not broadly used in our country.

Therefore, we have designed, implemented and refined an IBL activity for teacher initial training, as a way to promote the use of IBL methodologies in future teachers.

The opportunity to experience an IBL activity as students and to reflect on that as prospective educators could be a valuable tool, not only to improve their own science understanding and scientific process skills, but also, to develop interesting teaching competences for the application of IBL methodologies. The role of teachers in the implementation of IBL methodologies is a crucial factor affecting their success. Therefore, teacher training in IBL, entails drawing attention on how teachers should try to encourage reasoning rather the answer getting, build own students' previous knowledge and conceptions, and celebrate mistakes as opportunities for learning and improving, subtly showing students how they can work in profitable ways. It is also important to efficiently orientate group discussions, help students to make connection between ideas and highlight key ideas.

Taking into account the current interest in improving science education, the positive impact of IBL on science learning and the crucial role of teacher training and teacher professional development in the success of educational reforms, this pedagogical proposal may be considered as an interesting contribution to address these challenges.

NOTES

1. The Spanish Economic and Social Council, made up of employees' organizations, trade unions and other representatives of public interests, is a government advisory body, which means that its voice is heard in decision-making affecting the various sectors of Spanish society. The Spanish ESC studies and analyzes issues of concern to our society on its own initiative. Its annual memorandum has become an essential point of reference for understanding Spain's development and socioeconomic situation.
2. Bárcena, A.I., Ibánez, M.T. (2001). Estudio de la influencia en el aprendizaje de los alumnos de educación secundaria de una metodología de investigación para la resolución de problemas: aplicación para la enseñanza de la química y la biología. Available from: Redined Database.
3. Sierra, J.L. (2004). Integración de las tecnologías electrónicas de la información en la enseñanza de las ciencias mediante estrategias de investigación. Available from: Redined Database.
4. In Europe there are some international initiatives that are focused on changes of teaching sciences. An international team of expertises has established a multinational research network to work and offer a more widespread uptake of IBL. The PRIMAS project (*Promoting Inquiry in Mathematics and Science Education across Europe*) perseveres on a change in teaching and learning of mathematics and science at different educational levels across Europe, providing the necessary to support teachers in their professional development and supporting actions to develop, disseminate and implement the IBL.
5. The full activity can be downloaded from: http://www.primas-project.eu/artikel/en/1140/Hydratation+of+legumes/view.do

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MATHEMATICAL AND SCIENTIFIC WELLBEING (M/SWB): BROADENING THE ORIGINAL CONSTRUCT

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Abstract: For years it has been well known that there is an association between student affect and performance in school science and mathematics. However the intricacies of this association are still being teased out. In the current political environment when educational institutions are being explicitly asked to foster an environment that promotes student general wellbeing, this particular association takes on a new and significant meaning. But at the same time politicians and others in the community insist that narrowly defined cognitive performance is everything in mathematics and science (e.g. debate on PISA results). Within this old but still crucial area of research, we propose a new construct which we believe will move the debate forward. There are few tools with which teachers can gain insight into their students' wellbeing. In this theoretical paper we seek to broaden a construct, originally developed with mathematics in mind, for use in both science and mathematics classrooms. The construct should be useful in identifying and tracking students through a series of levels that will give an indication of how the students are coping emotionally in mathematics and science learning contexts. This construct grew out of our work on values in mathematics, combined with notions we found in the wellbeing area. We now draw on the science education research literature as well.

Keywords: Wellbeing; Science learning; Affect; Emotions; Values

PURPOSES AND PERSPECTIVES

Time was when the aim of learning mathematics was only perceived in cognitive terms. Later came the acceptance of the necessity to consider affective objectives, not just as an adjunct to the cognitive, but also as a 'driver' of mathematical learning, or non-learning (e.g. McLeod, 1992). A similar story is found in the science education literature where affect is now taken as a crucial issue for learners (Sinatra, 2005). Central to a deeper understanding of the role played by affective aspects in these learning contexts was the teasing out of what these aspects were. We and others have argued elsewhere that a pivotal aspect was the notion of values, although there have been difficulties translating this research into classroom action (Bishop, Gunstone, Clarke & Corrigan, 2006*;* Clarkson & Bishop*,* 2000). We now propose that a consideration of wellbeing offers a new way of recognizing the importance of the emotional aspects of, and the underlying values embedded in, mathematics and science learning.

"The literature does not provide a consistent definition or framework to measure wellbeing" (Ngyen, 2011, p.2). Nevertheless, notions of wellbeing in schools have mainly been envisaged as a generalist issue and often in terms of a healthy life (Catholic Education Office Melbourne, 2008; Lovat & Toomey, 2010). But for this notion to be a driving force for the betterment of students, wellbeing needs to be conceptualised as a core component of the school.

Hence for notions of wellbeing to impact directly on students, it needs to be conceptualised for the key subject areas and not left as a generalised feel good idea unattached to the core of what schools teach. These key subjects must include mathematics and science since the time students spend studying these subjects ranges from 25-40% of total school time. As well these subject areas are normally recognised by society as pivotal in students' education.

Interestingly Ngyen (2011) in reviewing the literature on wellbeing notes that teachers are in the better position to assess students' wellbeing, rather than rely on subjects' self-rating. The purpose of this theoretical paper is to introduce a new construct for teachers' use, dealing with the emotional state of students when they engage with mathematics or science; the *Mathematical / Scientific Wellbeing (M/SWB)* construct. This is the outcome of the first phase of an ongoing project. Following an introduction to the construct, we note references to a possible research agenda built around this construct and how it may impact on teacher education programs. We then comment on the responses of a small group of teachers to the construct, and conclude by reflecting on the significance of this work in progress.

DEVELOPING THE CONSTRUCT

A healthy sense of mathematical or scientific wellbeing should enable students to understand and apply mathematical and scientific concepts more effectively and in more sustainable ways, both in and beyond their school years. A positive wellbeing we argue is associated with the valuing of resilience, confidence, engagement, curiosity and efficiency; all values that are important not just for learning mathematics or science at a deep level, but also in living our daily lives. On the other hand, student disengagement in mathematics and science is an ongoing problem confronting most schools. Such disengagement would seem to be associated with a loss of wellbeing in the specific mathematical or scientific learning contexts. By the middle of elementary school it seems many students have become fixated on avoidance behavior towards these subjects. We came to believe that science and mathematics teachers could well do with a guide to help in gauging students' emotional responses. We also wondered if teachers were more aware of students' potential emotional responses, would they plan their lessons differently.

Our conception of the original *Mathematical Wellbeing* construct (MWB) was a series of stages through which we suggest students progress (Clarkson, Bishop, & Sear, 2010a). We summarise the main ideas of the original MWB in Table 1, but in that Table we have adapted it to speak to the science learning context as well (hence M/SWB). We have thought of the learner progressing through these stages as a state of wellbeing is consolidated. Age will be no definitive guide since we think that learners will be at different stages irrespective of age. Teachers may see aspects of cognitive development, but again this will not necessarily point to an M/SWB stage. Although we would generally expect this to be the case, we also know some students may well be developing cognitively, but still heartily dislike the subject. Alternatively, emotional growth may appear to be robust, but in fact it may be superficial, related only to some particular aspect of the learning situation, such as the behaviour of other learners. Clearly there is much to explore here.

As a student develops his/her M/SWB, we should see features of cognitive and affective objectives being satisfied at each stage. For example, a student who has been feeling a greater sense of M/SWB might be beginning to respond more positively to mathematical or scientific activities (that is, stage 2) and either knows or comprehends the demands inherent in these activities or tasks (cognitive domain), at the same time that the act of responding is reflective of affective educational objectives. At the same time, generally we would expect the interaction between M/SWB and growth in cognitive and affective objectives to feed on each other; given that a positive sense of wellbeing should stimulate self-confidence and foster enabling attitudes. Hence, if this interaction between M/SWB and cognitive/affective growth is mutually dependent and influential, then our ongoing quest to confront student dis-engagement (one of many manifestations of M/SWB) takes on new meanings, highlighting the importance of adopting a multi-prong approach involving cognitive, affective and emotional considerations.

Table 1: Modified stages of the construct ‘M/SWB’ (original in Clarkson, Bishop & Sear, 2010a)

Stage 1: Awareness and acceptance of mathematical and/or science activity:
The learner is aware of mathematics or science (M/S) as a non coherent collection of activities that is different in nature to other subjects. Although feeling comfortable in the context, has only a passive acceptance of such experiences and is disinclined to seek them out.
Stage 2: Positively responding to mathematical and/or science activity
M/S activity invokes a positive response. Indeed there is a welcoming of it and some pleasure in its pursuit and achievement, leading to feelings of self-confidence and positive self-esteem, which reinforces the acceptance and worthwhileness of such activity in general.
Stage 3: Valuing mathematical and/or science activity
The learner appreciates, enjoys and seeks out M/S activity, and people with whom these can be shared. Awareness grows of the human development of this knowledge, and of one’s place in the M/S scheme of things. The learner reaches acceptably high (to them) levels of competence.
Stage 4: Having an integrated and conscious value structure for mathematics and/or science
The learner values M/S and starts to appreciate future possibilities. This builds confidence in their level of skill, competence and judgments of their own strengths/weaknesses.
Stage 5: Independently competent and confident in mathematical and/or science activity
Now a fully independent actor on the M/S stage for their level. Can hold one’s own in arguments and is able to criticise other’s arguments from well-rehearsed M/S criteria.

We also suggest that students attain cognitive and affective educational objectives to different degrees at every stage of their mathematics learning and at any one time these are shaped by the student’s state of M/SWB. The higher order functioning in both the cognitive and affective realms involves the evaluation and finetuning of an individual’s value system, which in turn results in an increasingly integrated and conscious value system that regulates M/SWB. Such higher-order functioning constitutes a student’s life skill as he/she leaves school and contributes to the economic and social lives of the society. In other words, a more successful school education equips the student with this level of independence and wellbeing to deal with the many types of issues one comes across in life. At this level of personal growth, values and wellbeing are both stable enough to be regulating, but at the same time fluid enough to allow for adjustments as new insights and experiences 'makes one wiser'. This dynamic relationship between values and wellbeing has been investigated in contexts which are not directly related to mathematics and science education, but we suspect the same relationship will hold (e.g. Amin, Yusof & Haneef, 2006; Douglas, 2005; Eckersley, 2004).

The fostering of positive M/SWB needs to take into account how individual values have been – and continue to be – shaped and harnessed. For example, the successful cultivation of a student's valuing of *resilience* and *hard work* presents the student with opportunities to respond to intellectually challenging instances in his/her mathematics learning experience with a positive and enabling M/SWB. Alternatively, a student's valuing of *creativity* will likely support a more positive approach to novel problem situations, boosting his/her M/SWB in the process. On the other hand, one could picture a senior student who has developed over many years a relatively negative M/SWB. Her higher-order cognitive, affective and emotional functioning has shaped this outcome. But this outcome need not be regarded as a given that is fixed for life. By recognising this combination of cognitive, affective and emotional functioning, there is the potential for creative and purposeful designing of learning activities to stimulate such a student's independent critique and reviewing competence, to potentially redefine her M/SWB. This is highly complex, but at this level of functioning, the learner is well-equipped to evaluate cognitively, rationalising her emotional experience and decisions, in ways which characterise her being and wellbeing.

SPECULATION ON FURTHER EXTENSIONS AND INITIAL REACTIONS

In our original development of this construct we have suggested a research agenda (Clarkson, Bishop & Seah, 2010a) and how the construct may impact in teacher education (Clarkson, Seah & Bishop, 2010b) which we are also envisaging will apply to science. Here we briefly note some teachers' initial reactions. We asked eight teachers, after reading part of a chapter we had written outlining the MWB, to "Make some comments in relation to the MWB: in the way it is written, and why and how it could be used in your classroom." Each teacher wrote about one page of comments. Our analysis suggests that all of them saw value in such a construct and they said unequivocally that it would be used in their classrooms, with some suggesting that it could be reworded for students to also use. They noted "the sense" of interleaving the cognitive, affect and emotional aspects of learning into one construct, and thought exploring this with students would mean "the learning of mathematics (would be) more worthwhile in the eyes and minds of the learner." In effect the teachers thought that the use of the MWB construct would bring about a greater "sense of learning and engagement" for students well beyond the cognitive outcomes that seem to be the only valued outcomes for assessment. We have little doubt that we will receive similar feedback from teachers when we ask them about the M/SWB.

CONCLUSION

The M/SWB construct highlights the fundamental place of students' emotional development, an issue that has been gradually acknowledged, although only implicitly, in recent years within mathematics and science education. By building this construct we have tried to give depth to this issue and provide a possible way forward for addressing students' emotions when engaged with science and/or mathematics. We know that although many students master the procedures of mathematics and science, rarely does any sense of achievement ultimately remain. Rather it is their emotional dispositions (normally highly negative for mathematics, and for science 'it was sometimes fun but ultimately useless'), and the sense they made of the inherent mathematical and scientific values, that linger on through life (Clarkson, Bishop, Seah, & FitzSimons, 2001). We suggest that those students who positively responded to mathematical and science activities (M/SWB Stage 2 and further) are the ones who look back on their mathematics and science in school as engaging experiences. These are people who move into a long lasting sense of M/SWB, and hence can be much more productive within their society, and more constructive as they talk to their acquaintances and children about the good times of doing mathematics and science. Clearly there is much to be done in mathematics and science classrooms to reinvent these places of learning. A refocusing on values and emotions we believe will help to bring a greater sense of our students' M/SWB.

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THE CHALLENGE OF IMPLEMENTING IBL CROSS-CULTURALLY AND CROSS-CURRICULARLY

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Abstract: Facing the increasing lack of skilled workforce based on the declining interest of students in science and technology, the European Commission suggested a more appropriate implementation of natural sciences in the education systems. Therefore, several approaches have been made to improve the situation in school, among them the development of the Photonics Explorer (PEx), an educational kit funded by the EU. Since inquiry-based learning (IBL) is an accepted method to promote students' interest and motivation and improve the image of science and technology, the included didactic framework of the hands-on experiments in the kit is based on IBL. The aim of this study is to investigate the impact of the PEx on the students concerning interest, self efficacy and the image of physics.

In this paper we present selected results of the pilot study that has been conducted in Germany. It is shown that both the amount of IBL and being engaged with the PEx influences the students' image of physics. The field test will show to what extent the PEx has an impact on the students and reveal the differences of its educational value for each of the participating countries.

Keywords: Inquiry-based learning, experimental kit, optics, European project, educational material

BACKGROUND, FRAMEWORK AND PURPOSE

The lack of skilled workforce is an increasing concern for Europe's high-tech industries. One reason for this lack is the low interest of young people in science and engineering and the negative image of physics they already have in school (PISA Consortium, 2007; COM, 2009). As has been criticized by Hofstein and Lunetta (1982, 2004) students seldom experience real scientific methods and inquiring activities in school although experiments are an essential part of scientific work and experimental equipment used in class is mostly out-of-date (Tesch 2005). Many students consider physics boring and unattractive and therefore drop it as early as possible.

Inquiry-based learning (IBL) methods support the students to deal with real scientific work and raise certain research questions and also foster their scientific skills. They have a proven "efficacy at both primary and secondary levels in increasing children's and students' interest…" and additionally help students to develop a "critical thinking and reflection (…) to make meaning out of gathered evidence" (Csermely et al. 2007, p.2). However, teachers still seem to emphasise science concepts and facts rather than problem solving and critical thinking (Rennie, 2007). But even though IBL methods are seen as very effective way to achieve the goals of a knowledge based society and increase scientific literacy of its citizens, they are rarely implemented in classroom practice (Csermely, 2007).

The complexity of today's social, political and technological environment leads for many people to increasing troubles in understanding their surrounding world (Dubs, 2002). This is in line with the realization that the future competitiveness of a country strongly depends on the quality of education, especially in science and technology. The Rocard report even stated that "(...) among the population in general, the acquisition of skills that are becoming essential in all walks of life, in a society increasingly dependent on the use of knowledge, is also under increasing threat" (Csermely, 2007).

In order to link the goals of raising the interest of students in physics and to ensure scientific literacy among European's citizens, several approaches have been proposed. The EU funds numerous projects, among them the development of an educational kit to encourage students and teachers to extend scientific inquiry and to promote the interest of young people in science and technology in the field of photonics. This kit (Photonics Explorer, PEx) is an intra-curricular kit that will be handed out free-of-charge to teachers in Europe. The aim of the project is to promote the students' discovery and development of certain scientific and technical competencies, foster their open-mindedness for science and improve the image of physics in school.

In the development process of the PEx a group of experts in photonics, didactics and teachers from more than 10 countries were involved. The developed material contains robust and versatile components for hands-on work in small groups of two or three students to make sure everyone can be part of the investigation team. The provided worksheets of the PEx open with an every-day related topic that introduces the theme of the module to the students. The group is then asked to examine a given task and afterwards come up with its own ideas for an unknown problem. At the end, the whole class discusses its findings and sometimes presents the results in small groups. For each module a fact sheet is handed out that summarizes important aspects and facts to remember for the students.

The present paper sets focus on the question whether being actively engaged with the Photonics Explorer leads to an improvement of the image of physics.

RATIONALE

The survey determines among other things the effectiveness of the PEx on the improvement of the image of science, depending of the amount of IBL the students already have in their classes. In the present paper the results of the pilot study in Germany are shown and the challenges for the implementation of the PEx in 7 European countries are indicated.

METHODS

The image of physics has been acquired through a semantic differential based on the CAEB study (CAEB: An instrument of measuring connotative aspects of epistemological beliefs) by Stahl and Bromme (2007). Different adjective pairs have been chosen where the PEx is supposed to have an impact: important-unimportant; open-closed; exciting-boring; creative-uncreative; modern-old-fashioned; simple-complicated; fundamental-additional. The scale is referring on physics as a school subject. In order to specify the role of IBL, a latent class analysis was conducted to differentiate the students by the amount of IBL methods they have already experienced in their class.

A pilot study was conducted in March in Germany with 3 lower secondary schools classes (age 13-14) and with 3 upper secondary school classes (age 16-18). Overall, around 140 students have been participating in the pre-post-follow-up survey with paper and pencil. The students received the first questionnaire shortly before starting with the PEx in class (T1), one directly afterwards (T2) and one two months later (T3).

RESULTS

To show the impact of IBL methods in class on the students' image of physics, a latent class analysis was conducted. The best fit parameters were found for 3 different groups of students which are distinguished by the amount of IBL they already experienced in physics lesson so far (small, medium, high).
The use of the PEx in class leads for all students to significant changes in the aspect 'creative' but after two months they find physics as even more 'uncreative' as before starting with the PEx. Conducting experiments with the kit leads to physics lessons appearing 'simpler' which remains constant over the two months. In the follow-up-test the students stated that after finishing with the material in class the physics lesson changed significantly to 'boring' (data not shown).
The comparison of images of students with a high, medium resp. small amount of IBL methods in class reveals a different picture. As can be seen a significant difference already appears before starting with the PEx. The first group of students has a rather positive attitude towards physics (Fig. 1) as has the second group except for the aspects 'simple' and 'additional' (Fig. 2) while the third group has crossed more negative aspects throughout (data not shown).

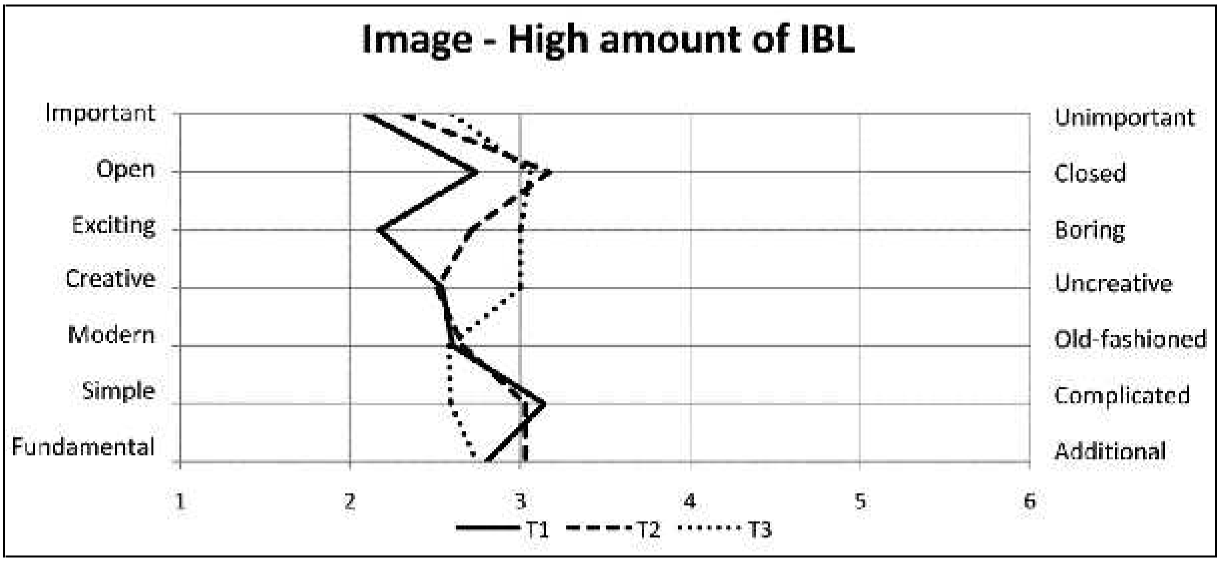

Fig. 1 Changes in the image of physics for students with a high amount of IBL in class

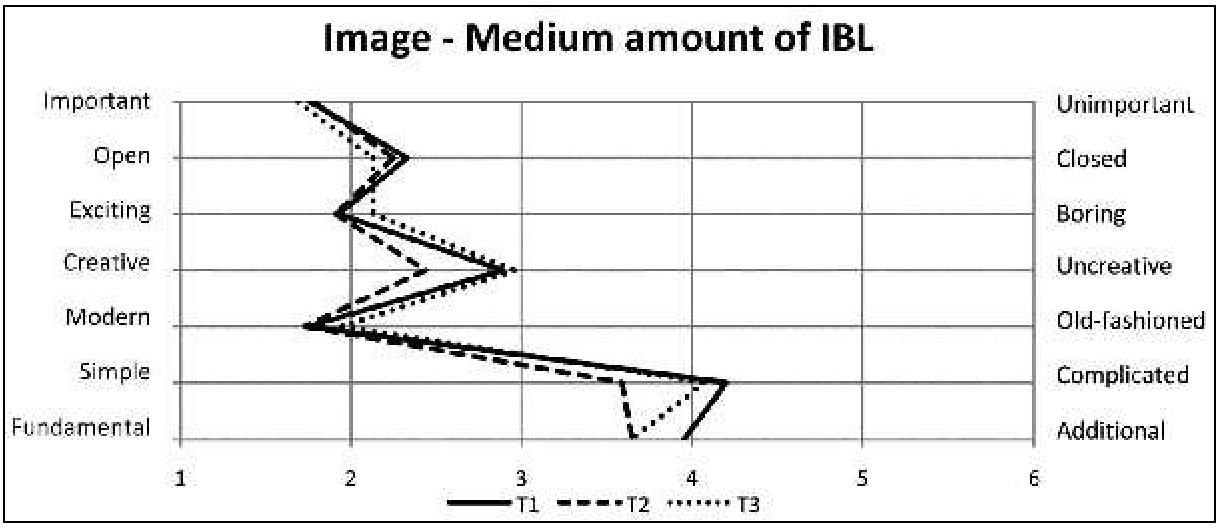

Fig. 2 Changes in the image of physics for students with a medium amount of IBL in class

For the group with high amount of IBL methods the treatment shows significant changes to ‘simpler’ but ‘more boring’. After the two months physics appears to be less ‘important’ and ‘simpler’ together with even more ‘boring’ than right after the treatment (see fig. 1). In the second group (medium amount) working with the PEx leads to the impression that physics is more ‘creative’ and ‘simpler’ which is not stable over the time of two months but decreases to the previous value. The usual physics lessons seem less attractive after working with the PEx, students experience physics as more ‘boring’ after two months (see fig. 2). On the contrary, the group of students with the small amount of IBL methods in class reveals no significant changes in all items (no data shown). In neither of the last two student groups does the PEx have an impact on the question of the importance of physics.

CONCLUSION, IMPLICATIONS AND CHALLENGE

The comparison of the two student groups suggests the assumption that using IBL methods in class lead to different images of physics in classrooms. Considering that the participating classes only tested one module out of four, we can expect greater changes in the different aspects of image due to the additional time the students are using the PEx. During the field test, the implementation of IBL methods will also be evaluated and would indicate a positive image of physics as could be seen on fig. 1 and fig. 2.

A big challenge that the project is facing in the test phase are the totally different curricula of the participating countries. As has been revealed by a re-analysis of the PISA study from 2006, the existing teaching-styles in the test countries reach from IBL methods with experiments on one side to teacher-centred on the other side (see fig. 3).

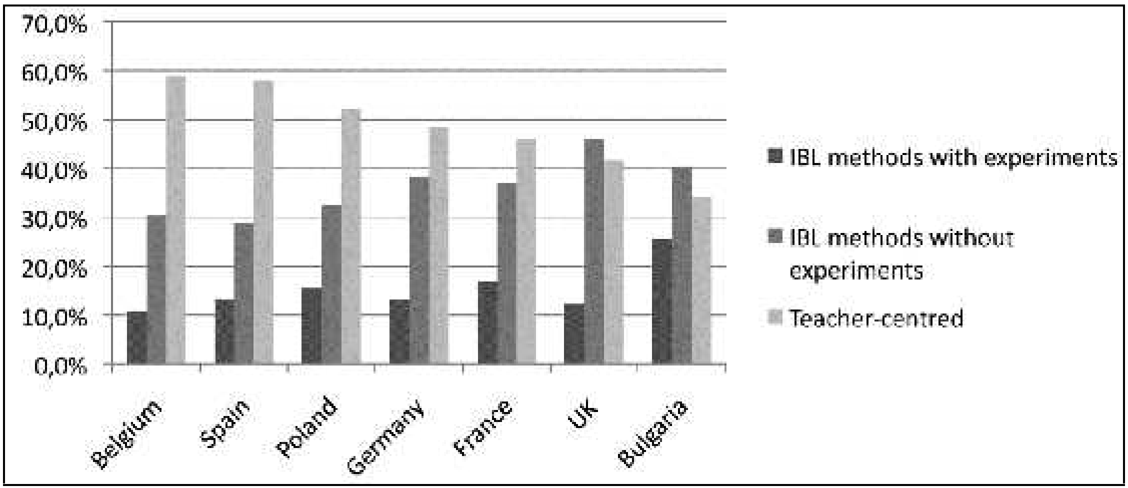

Fig. 3: Different teaching-styles in the participating countries of the project (Re-analysis of PISA 2006)

Being actively engaged with the PEx indicates a positive change on the students' image of physics. The students get the opportunity to attend the school topics in a different and rather autonomous and creative way. Therefore, the image changes to more 'creative' since it is not mere reproduction. They conduct experiments in small groups and get less instruction than in the usual lesson. Working hands-on is supposed to inseminate a different sense for experimenting und bring the students closer to the work of a real scientist.
The field test will show how the students learn in the other participating countries and how the implementation will work out in order to assess the impact and educational value of the PEx.

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REPRESENTATION USE AND STRATEGY CHOICE IN PHYSICS PROBLEM SOLVING

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Abstract: In this paper, we report on student success on a test item given in three different representational formats (verbal, pictorial and graphical), with isomorphic problem statements. We confirm results from recent papers where it is mentioned that students' problem solving competence varies (often strongly) with representational format.

Previous studies are complemented with a fine grained analysis of solution strategies. We can conclude that students use different problem solving strategies, depending on the representational format in which the (physics) problem is stated.

Keywords: physics, problem solving, representations, strategy choice

1 INTRODUCTION

Student competence with different representational formats gets lot of attention in recent research on physics and mathematics education. By 'representational format', we refer to the many different ways in which a particular problem or concept can be expressed, such as a graph, picture, free body diagram, formula …

Being skilled in using different representations and in coordinating multiple representations is highly valued in physics, both as a tool for understanding concepts (Kozma, 2003; McDermott, 2004) and as a means to facilitate problem solving (Dufresne, Gerace, & Leonard, 1997; Heller, Keith, & Anderson, 1992; Larkin, 1983; Reif, 1995; Van Heuvelen, 1995; Van Heuvelen, & Zou, 2001). Expert physics problem solvers are fluent in their use of different representations, can easily translate between them and can assess the usefulness of a particular representation in different situations. As it is a principal goal of most physics courses to produce adept problem solvers, a possible instructional aim might be to develop this representational fluency in physics students in order to benefit from using multiple representations.

There have been a number of studies that examined student performance in particular representations of physics problems, both inside and outside of Physics Education Research (PER) (see, e.g., Meltzer (2005) for a short overview). There also have been studies that compare student performance on problems that involve multiple representations to performance on problems that involve one single representation (Ainsworth, Bibby, & Wood, 1998; Mayer, 2003) and studies that investigate student skill in translating between representations (Kozma, 2003; Schnotz, & Bannert, 2003). A third group consists of studies in which students are explicitly taught to handle multiple representations of the same topic. Roosengrant, Etkina and Van Heuvelen (2006) give a short overview of recent literature on the use of representations in PER.

The line of research in which the current study fits, focuses on the relationship between student success and the representational format in which the problem is posed: how does the representation in which the problem is formulated affect student performance and solution strategy (Koedinger, & Nathan, 2004; Kohl, and Finkelstein, 2005; Meltzer, 2005)? Answering this question is not only interesting from a theoretical point of view, but also from an instructional perspective. If it turns out that a particular representation is more suited to solve a specific kind of problems, it is important to train students not only in working with different representations and translating between them, but also to teach them how to choose adaptively an appropriate representation.

Both in the work of Meltzer (2005) and of Kohl and Finkelstein (2005) student performances on problems in different representational formats (verbal, mathematical, graphical and pictorial or diagrammatical) were compared. Both author groups conclude that student performance on nearly isomorphic problems (quiz and homework) stated in different representations, varies significantly. When there was a performance difference between two formats, the ‘mathematical’ format often was one of the formats involved. Results show that on average, students were more successful in the mathematical format (or a format in which a numerical calculation can lead to the solution), which is consistent with the idea that first-year students are more comfortable with ’plug ’n chug’ types of problems than with conceptual questions (Mazur, 1996). Kohl and Finkelstein broadened their investigation by giving a group of students a choice of formats (before they read the problem), and by comparing the results of students in the choice condition to the results of students that were randomly assigned one of the four representational formats. It was found that allowing students to choose did not consistently increase or decrease success relative to the control groups, but that the effect varied strongly both across topic and across representation.

In this study, we use items mentioned in the paper by Kohl and Finkelstein (2005) as a starting point to replicate part of the study. Student answers are studied and results are compared to the outcomes mentioned by those authors. Moreover, we broaden their investigation by asking the students for an explication and we extended the analysis by studying the written justifications in detail. These written explanations allow us to study the physical concepts and the problem solving strategies that students use.

The main research questions thus are:

1. Do students perform differently when solving a physics problem formulated in different representational formats?
2. How are the solution strategies of students affected by the representation used in the problem statement? Do students use different solution strategies in different representations?

2 METHOD

The study was conducted in a large-enrollment (± 200 students) introductory physics class. Students are typically first year students, all taking the mandatory course as part of the pharmaceutical science program. Students’ math skills are quite varied. The course in this study was a first semester class in the fall of 2009. The format of the course is mostly traditional, with some in-lecture concept tests. Students have two two-hour lectures per week, and meet for three hours each week in a traditional recitation session. Besides the lectures and the recitation sessions, there are three three-hour lab sessions. Students’ grades were based on exams, labs and homework assignments. Homework problems consisted mainly of qualitative conceptual problems (online).

Here, we report on student responses to a selected mid-term exam question: one research item was included in the questions of a mid-term test. Participation in the test was free and test results did not count for the students’ final grade. The representational format in which the research item was formulated, was randomly varied between students. The test item we used to study representational competence is a translation of the verbal, graphical and pictorial version of the question on energy and energy transformation developed by Kohl and Finkelstein (2005) and is shown in Figure 1. Because the main focus of the test was on conceptual understanding, it was decided not to use the mathematical format, where the original item was explicitly asking to compute a (numerical) speed.

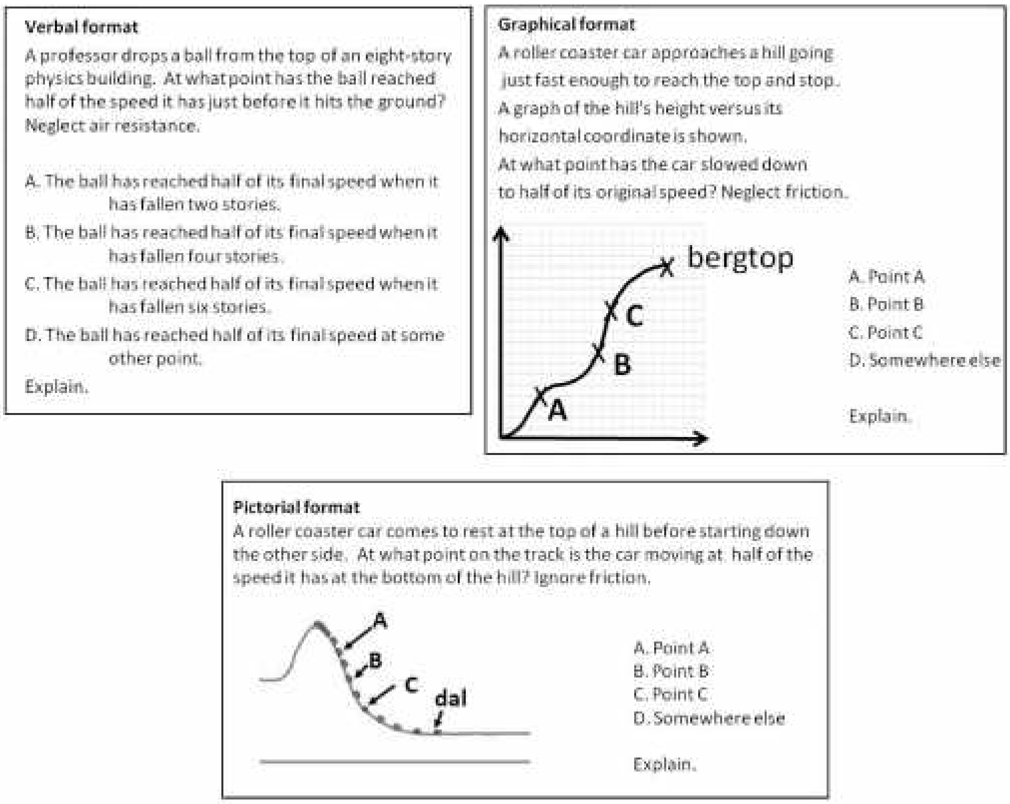

Figure 1: Verbal, graphical and pictorial format of the test item, adapted from Kohl and Finkelstein (2005)

As mentioned in the original article (Kohl, & Finkelstein, 2005), these problems are meant to be isomorphic from format to format, with the answers and distracters mapping from one format to the other. By isomorphic, the authors mean isomorphic from the point of view of a physicist. The test items that we used differ from the original ones in the sense that we do ask the students to explain their choice. Both the choices of the alternatives and the written explanations are studied in detail.

When studying the items as pure multiple choice questions, we only take into account the alternative picked by the students, without considering the explanations. This means that also choosing the correct alternative with an erroneous reasoning or without an explication is counted as correct. However, when taking into account explanations, an argument is only evaluated as ’correct’ if it consists of a correct physics reasoning and a correct conclusion. An incorrect physics reasoning or a mainly correct argument but with a wrong conclusion is considered incorrect. Answers without justification are categorized as incorrect.

3 RESULTS

In this section, we compare student performances on the test problem in different representational formats and focus on the solution strategy that students choose in the different formats.

Performance in different representational formats

In Table 1, the fraction of students that answered the test item correctly is shown, not taking into account their explanations. The number of students answering the question in the particular formats is given in parentheses.

Total number of students:189	Verbal (N=62)	Gaphical (N=64)	Pictorial (N=63)
Correct alternative	0.44	0.28	0.33
Correct alternative + correct justification	0.40	0.06	0.13

Table 1: Fraction of students answering correctly, broken down by representational format

All statistical significance tests involving student success rates are two-tailed binomial z-tests. We consider a difference with $p > 0.10$ as not significant, p between 0.10 and 0.05 marginally significant, p between 0.05 and 0.01 significant, and $p < 0.01$ highly significant.

When considering only the answer options (a-b-c-d) and not the explanations (Table 1), the difference between the verbal and graphical format is marginally significant (p=0.07), whereas the other differences are not significant. This is in line with the results in the original paper (Kohl, & Finkelstein, 2005).

However, when taking into account the explanations given by the students, results look quite different. Table 1 also shows the fraction of students choosing the right alternative, AND giving a correct explanation for their choice. When comparing these results, we find that the differences between verbal and graphical format and between verbal and pictorial format are highly significant (p=0.0006 and p=0.001 respectively), whereas graphical and pictorial format do not differ significantly from each other. It is almost immediately clear that the fractions of correct answers with or without taking into account the explications, do not differ significantly for the verbal format (p=0.72), but the difference is highly significant for the pictorial (p=0.006) and the graphical format (p=0.001).

Solution strategy in different representational formats

As we did not expect these results, we looked in detail at the students' explanations in order to find out how these differences can be explained. We found that students justify their answers differently in the different (representational) formats. Some explanations are based on kinematics, some on conservation of energy or on a linear reasoning. There also were arguments which are strongly tied to the visual information in the representation. In what follows, different solution strategies are discussed.

Conservation of energy versus kinematics
In Table 2, the fractions of answers using kinematics and conservation of energy (not necessarily in a correct way) are shown for the different formats.

Total number of students:189	Verbal (N=62)	Gaphical (N=64)	Pictorial (N=63)
Fraction of explications using kinematics	0.56	0.22	0.14
Fraction of explications using energy conservation	0.23	0.34	0.43

Table 2: Fraction of answers with justification based on kinematics and conservation of energy in different representational formats

The difference between fractions of answers using kinematics in the verbal and graphical format is highly significant (p=0.00006), as is the difference between the verbal and pictorial format (p=0.00006). The difference between the graphical and pictorial format is not significant.

When comparing the fractions of answers based on conservation of energy, the difference between verbal and pictorial format turns out to be significant (p=0.016), while the other differences are not significant.

When looking within the different formats, it turns out that the fraction of students using a kinematics argument differs significantly from the fraction of students writing an explanation based on conservation of energy for the verbal (p=0.0001) and pictorial format (p=0.0004). However, for the graphical format, the difference between the fractions is not significant. In the verbal format, more students solved the problem using kinematics than using conservation of energy, whereas for both other formats, more justifications are based on energy conservation. Out of the 25 students that solved the item correctly in the verbal representation, 18 of them justified their answer using kinematics, while only 6 students based their argumentation on conservation of energy. One student used a correct combination of conservation of energy and kinematics to explain his answer. In the graphical and pictorial format, none of the explications based on kinematics is correct. The correct explanations in these formats are all based on conservation of energy.

These results suggest that the different formats are not completely isomorphic: the verbal format is one dimensional and as such leaves the possibility to solve the problem using kinematics. This is not the case for the other two formats, where the two dimensional (2D) character prevents the easy use of kinematics. More interestingly, the results also suggest that, if possible, students are more likely to apply kinematics than to apply conservation of energy. However, the data for the graphical and pictorial format seem to suggest that students are aware of the difficulty of the use of kinematics in these situations: a smaller fraction of students uses a kinematics argument in these situations than in the verbal formulation.

Conservation of energy

In a next step, we studied the 'conservation of energy answers' in detail. We found that a lot of students had trouble to apply the principle of conservation of energy correctly. In Table 3, we present the number of students using a correct conservation of energy explication.

	Verbal (N=16)	Gaphical (N=26)	Pictorial (N=21)
Correct application of energy conservation	0.43	0.18	0.30

Table 3: Distribution of answers using a correct argument based on conservation of energy

Although, from Table 2, we see that the fraction of students using a conservation of energy argument does not differ between formats, Table 3 shows that in these arguments, more errors are made in the graphical and pictorial format, compared to the verbal format.

Linear reasoning

An interesting distracter is answer *b* in each of the formats. This alternative could correspond to a 'linear reasoning': 'half of the final speed is reached halfway'. In mathematics education, a vast amount of research has shown that students have a strong tendency to apply linear or proportional models anywhere, even in situations where they are not applicable (De Bock, Vandooren, Janssens, & Verschaffel, 2007). In Table 4, the fraction of linear answers (i.e., the fraction of students answering alternative *b*) is given for the different formats.

Total number of students:189	Verbal (N=62)	Gaphical (N=64)	Pictorial (N=63)
Fraction of linear answers	0.13	0.42	0.33

Table 4: Fraction of students choosing the linear alternative in the different representational formats

It turns out that the difference between verbal and graphical and verbal and pictorial format is highly significant (p=0.0002, and p=0.007 respectively). The difference between graphical and pictorial format is not significant (p=0.3).

Analysing the explanations of students picking alternative *b*, shows that not all of them refer to a linear reasoning (e.g., stating 'the car will have half of its final speed halfway'). On the contrary, most of them use (wrong) energy or kinematics arguments. In the verbal format, 4 (out of 8) students refer explicitly to a linear argument to pick alternative *b*. In the graphical format, 7 out 27 use a linear reasoning, while in the pictorial question, only 2 students (out of 21) use this kind of argument.

Representation dependent cueing
From the above, it is clear that both performance and problem solving strategy used by students differ between representational formats. Conservation of energy, kinematics and linear reasoning are already mentioned, but another class of arguments seems to be strongly related to the representational format: quite a few students explain their choice by referring to the slope or tangent in the picture or graph in the question, thereby mistaking the position (time)-graph with the picture of the hill or the vertical direction (horizontal direction)-graph. 7 students (11%) make this mistake in the pictorial format, 10 (16%) in the graphical but, of course, none in the verbal version.

4 DISCUSSION AND CONCLUSION

In this study, we did investigate the role of representational format in student performance when solving physics problems. The work of Meltzer (2005) and Kohl and Finkelstein (2005) indicates that student performance can vary strongly with the representation used in the formulation of a question. By asking students for detailed explanations, we gained more insight in these differences. Kohl and Finkelstein suggest that performance differences depend on a number of things, including student expectations, prior knowledge, metacognitive skills, and the specific contextual features of the problem and the representations. Moreover, they argue that different problem representations might prompt different solution strategies.

Only one test item is included in this study, but as we asked students to explain their choice, we could study the strategies used by the students. This detailed study confirmed the performance difference across representations and revealed that these differences can - to a large extent - be explained by the fact that students use solution strategies based on different physics ideas to explain their answers in the different formats. The problem formulation of the verbal format allows both the use of 1D kinematics and conservation of energy to solve it. This is not the case in the graphical and pictorial formats, where students preferably use conservation of energy to argue their choice. Detailed analysis of the data do confirm that students use the 1D kinematics often in the verbal format and that most of the correct answers are based on a kinematics argument. The number of correct explications based on conservation of energy is surprisingly small, in all three formats.

With quite some students arguing based on the slope in the picture or graph, we found evidence consistent with the idea that specific, micro-level features of a representation can prompt students to a particular solution strategy/argument, as is suggested in Kohl and Finkelstein (2005).

While this study did not have the intention to develop or test new instructional materials or techniques, we can speculate as to the instructional implications of the results. We have found another example in which student performance was significantly affected by which representation was used, and that impact could be tied to representation-dependent problem features that either cued an answer directly or changed the students' overall strategy. Instructor awareness of this sensitivity to representation would likely to be productive.

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WORLDVIEWS TO THE CONCEPT OF EVOLUTION AMONG STUDENTS IN AN INITIAL TEACHER TRAINING COURSE

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Abstract: The present work shows the close relation between evolution rejection and protestant fundamentalism in students from a teacher training course in Brazil, together with a discussion on the best approaches to deal with this situation. The imposition of science explanations was rejected together with those from relativistic interpretations of science.

Keywords: Biology Teaching; Science Teaching; Evolution; Creationism; Teacher Training.

BACKGROUND, FRAMEWORK AND PURPOSE

The debate opposing Science and Religion, although still held by some authors, has proved for many others to be misplaced and religious thoughts apparently still have an important place to take in the lives of many of the contemporary human beings, many times side by side with the acceptance of the most recent scientific developments and concepts. However, this does not mean, as proposed by Gould (1999), that Religion and Science peacefully took separate places in the minds of everyone as Non- Overlapping Magisteria.

Quite the contrary, the last century has witnessed the emergence of a typical modern phenomenon, named religious fundamentalism, which in the western countries had its major source in the United States of America in some conservative protestant denominations (Numbers, 2006). More directly related to Biology and Science teaching is the “scientific” facet of this movement, that albeit its religious motivations, presented itself initially as “scientific creationism” and lately was renamed by its followers as “intelligent design” (Alters & Nelson, 2002). This movement deeply opposes many of the basic ideas that form the core of the modern evolutionary synthesis and although initially restricted mainly to the United States (Scott, 2006), began to spread to other western countries especially through the activity of religious institutions.

As stated by Numbers (2006), nowhere in South America antievolutionists have made deeper developments than in Brazil, where this issue has been assuming an escalating importance and has reached its climax on March 2002, when the governor of the State of Rio de Janeiro, a Presbyterian politician supported to a great extent by the evangelicals, sanctioned the law that authorized the teaching of a new subject, “Religion”, in the public schools of the State. At the time the governor took the chance to declare her support for the biblical creationism and rebuffed the idea of biological evolution of the species.

The study herein reported was carried out in an initial teacher training program in Biological Sciences in the Universidade do Estado do Rio de Janeiro (UERJ) and is located in a municipality in the outskirts of the metropolitan region of Rio de Janeiro, Brazil.

This work aims to investigate the possible association between the religious affiliations of forthcoming Biology and Science teachers and their reactions to biological concepts related to biological evolution and its consequences. The research questions of this paper are: 1 - Is there any association between religious affiliation and rejection or resistance to the concepts related to biological evolution?; 2 - If such association is found, could it be more intense in some religions than in others? Which ones?; 3 - Which best strategies could be employed by forthcoming teachers of Biology and Science when dealing with this sort of conflicts? Which ones should not be encouraged?

METHODOLOGY

A survey of eleven questions/statements (eight dealing directly with biological concepts) was applied to all the students which agreed to participate in this study and that were following different periods in the teacher training program in Biological Sciences at the UERJ in the beginning of 2004. A total amount of 245 surveys were collected. Recorded interviews with five students from different religious affiliations were also included to complete the empirical basis of the research.

RESULTS

In almost all the biological questions of the survey, the highest percentages of disagreement between the evolutionary concepts and the worldview of the students came from those from a strong protestant background. In the first question, for instance, while 91.7% of Catholics agreed with the idea of kinship between different living beings, followed by 87.5% Non Religious students, and 84.2% of Spiritualists, only 76.5% of the Protestants did so. Besides that, among those that responded affirmatively to this question 50.91% of Catholics employed evolutionary arguments, followed by 45.83% non-religious students, and 42.11% of Spiritualists (second question). The lowest numbers (33.33%) came from the Protestants in which the typological arguments reached their highest level. The lowest percentages were also found among Protestants about the following statements: all living beings descend from a single form of life (third question, 18.4%); the human species came from another different species (fourth question, 38.5%); all species change throughout time (fifth question, 45.1%). Moreover, this was the only religious group to predominantly reject both third and fourth questions. Their answers were also quite unique since 35.29% chose the option “there is no proof that living beings change originating different ones throughout time” in the fifth question. On the other hand, their responses reached the highest levels in the following statements/questions: our species is the only rational one. Is there is a reason for that? (ninth question, 50.0% found a religious reason); what is the definition of evolution? (tenth question, 34.62% considered it only a hypothesis); have other species appeared after the origin of humans? (eleventh question, 46.15% answered negatively).

The only exception regarding the uniqueness of protestant responses to biological statements came from the eighth question, which inquired “what does it mean for a living being to be more evolved than other one?”. In all religious groups the most common answer was “more adapted/specialized”, revealing both a static view of the environment and a unidirectional conception of the evolutionary process, which misunderstands evolution as a process of species improvement (Protestants – 55.77%; Catholics – 46.55%; Spiritualists – 52.63%, and Non-Religious – 50.00%). In the second place, regardless of religious groups, came the answer that best expresses the evolutionary paradigm, in which the most evolved species are those “that suffered more changes throughout time” (Catholics – 34.38%; Protestants - 23.08%; Non-religious – 22.73%, and Spiritualists - 15.79%).

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

The results herein presented reveal a significant amount of rejection and resistance among a large group of students, not to a secondary peripheral area of Biology but to the central tenets that established this knowledge as science in its contemporary form in the first half of the 20th century (SMOCOVITIS, 1992). This rejection is by no means the result of cognitive difficulties or related to the shock of getting acquainted with a different and strange language held by the scientific community, since many of the students seem to master properly the major biological concepts they were taught and do well in most of the exams. Similar results have also been found in Brazil for future Biology teaching students by Sepúlveda & El-Hani (2010), for graduating students from different areas by Souza *et al.* (2009), for Secondary Education teachers (Tidon & Levontin, 2004), and for the pupils from elementary school by Fonseca (2008), showing that this is by no means an isolated situation and that forthcoming Biology and Science teachers should be aware of it.

The results of this work remark the importance of developing teaching strategies adequate to deal with this situation, one which surely takes into account the importance of "contextual constructivism", a term coined by Cobern (1994), which according to him would be a cultural constructivist approach. This view regards the learning process as a much more complex task than only a personal activity, always taking place in a social context.

In this way, we agree with McKeachie *et al.* (2002) that teaching strategies should involve not only the transmission of correct and up to date scientific knowledge but also need to create cognitive dissonance with some of the creationist thoughts so dogmatically held by some of these students. This dissonance should not be presented as an antagonist relation but fairly presented as worldview conflicts about certain issues to the students, remarking about the different fields in which they were supposed to act. Therefore, our main goal should be, as addressed by Pigliucci (2007), to move these students out of their comfort zones, opening their ideas to situations in which they are subjected to scrutiny and debate with other views. In this way, we should aim to foster situations that enhance the chance of argumentation by these students and that allow their interaction with new and unusual situations to take place. In this learning process the issues covered during the course are not important in themselves but the way they are used is central for the success of this methodology. However, this said, it is clear that some of them are more likely than others to promote heuristic dissonances. Various authors have suggested more promising subjects in Biology to deal with the teaching of evolution, and all of them have been proven useful in our classrooms.

Gregg *et al.* (2003), for instance, stressed out arguments based on the molecular level, such as the common structure of DNA, of the processes of protein synthesis, the presence of metabolic pathways identical in all living beings and the universality of the genetic code, among others, with the appeal not only from the logical arguments but also from the symbolic power carried nowadays by everything related to the structures and processes at the molecular level. Antolin & Herbers (2001) presented evidences of evolution through situations related to current issues from Medicine (development of microorganism strains resistant to antibiotics), Agriculture (selective breeding and the generation of different varieties of animals and plants), and Biotechnology (genetically modified organisms). Images of transitional fossils - especially those that do not clearly fit into those basic kinds or types found in present animals - , together with similar embryonic developmental stages in complete different adult animals, have also posed challenging questions to these students.

Also, as mentioned by Pigliucci (2007), it is important to follow the trajectory of those students that initially had a hostile attitude towards evolutionary concepts and later have managed to overcome these conflicts. The careful examination of their mediating strategies may provide important clues about what might work or not, always bearing in mind that although individuals have different stories, some general patterns and tendencies might emerge. Accordingly, when teaching evolution later, one of our former creationist students chose to deal with the most problematic issues later, not as a way to hide them, but in order to provide their pupils first with the basic knowledge necessary to better understand the process. Without this, their ability to fully comprehend all the arguments and inconsistencies present in the discussion would be seriously compromised and rejection would follow immediately.

This approach should be accomplished assuring the students that this is by no means a debate about Science *versus* Religion and so they must not be discouraged about their religious beliefs, therefore avoiding some aspects of science teaching criticized by Aikenhead (2002). This author has emphasized that in many instances science teaching acts as a dominating enterprise in which all students are exposed to a single culture disguised as neutral knowledge transmission. Otherwise, the same dogmatic attitude is strongly supported by most creationists in the opposite direction, and so should be answered likewise, that is, confronted with the power of debate and exploring the heuristic value of conflicts. These students come to the university bearing, at different degrees, a number of several dogmatic truths, most of them linked to the religious matrix they follow. Any other way of thinking presented to them that also work based on absolute certainties will surely be in disadvantage with their religious views. Therefore, the teaching of any dogmatic version of science, besides incurring in serious epistemological misinterpretations of the scientific activity, is also a weak and innocuous didactic strategy when dealing with these students.

We strongly believe that the best strategy is to present science as a field of questioning and discovery that almost always is tentative. This is a way of thinking that most of these students are unaware and that do not struggle for space directly with their religious views. For many of them, change and instability have necessarily a negative connotation and hence we should emphasize the importance of explanations that are not based on stability, but that rather work through critical revision, involving advances and retreats, disputes, loss of data and its recovery, besides having a generous space for stochastic phenomena. The teaching of this relentless movement is able to foster in these students the conditions necessary to better welcome some of the scientific explanations or at least debate them with consistent arguments, going beyond immediate rejection. Thus, the presence in our curriculum of a discipline about History and Philosophy of Science has helped us in teaching the nature of science, their limits and possibilities, allowing these students to recognize which explanations are parts of the scientific endeavor and which are not. The importance of the different contexts in which these explanations are applicable reveals its importance and religious explanations like creationism and intelligent design do not belong to the scientific field.

Finally, in a nutshell, our defense of a cultural constructivist approach of teaching science and its changeable nature should not be confused with some relativistic interpretations of the reality. Some of them consider any explanation of reality held by any group of people as valid as any other (including the scientific ones) based on the impossibility of seeing the real world as it is. This approach, very popular in some trendy academic circles, have been craftily framed by religious fundamentalists throughout the world in order to promote their agendas, creationism included (NANDA, 2003). Our viewpoint is based on the critical realism defended by authors like Chalmers (1993) and on our understanding that the debate between different cultures is not based on their essentialistic nature, rather considering them to be engaged under processes of multiple influence. Therefore, since knowledge is socially constructed, the best way to respect the members of a particular culture should be neither impose another foreign view over them nor isolate them from any debate and exchange with other experiences and points of view. This is especially true if the members of this group have cultural views that are based on dogmatic religious visions and are not living remotely isolated but in the outskirts of modern cities with an involuntary limited access to different sources of information.

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FORCE DYNAMIC GESTALT OF NATURAL PHENOMENA: TEACHING THE CONCEPT OF ENERGY

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Abstract: Modern cognitive science in general and cognitive linguistics in particular teach us about basic figurative structures of the human mind which are used to conceptualize natural, psychological, and social phenomena and processes. These figures of thought are based on schematic structures that develop early in the life of a child. We have identified a structure, the Force Dynamic Gestalt, which underlies both everyday language and reasoning and the formal science of physics. If teachers learn to make use of these figurative structures, they are in a position to produce well-crafted narratives with which they can confidently teach other- wise complex and formal subjects. We demonstrate how to use the approach for developing the energy concept in primary school. The method lends itself well to a deliberate movement from the affective and qualitative to the logical and quantitative, and to the use of role games, stories, outdoor activities, laboratory work, drawings, writings etc. Linguistic and graphical tools will be described that make this approach not only simple but also natural.

Keywords: Cognitive linguistics, image schemas, metaphors, force dynamic gestalt, energy.

1. INTRODUCTION

Many studies have identified "misconceptions" in pupils' understanding of the energy con- cept. Some researchers (Solomon, 1983; Watts, 1983; Duit, 1984; Trumper, 1990, 1991; Log- man et al., 2010) have created categories and conceptual frameworks for describing children's ideas concerning energy. Krugher et al. (1992) found that teachers often share these same na- ive ideas. Generally, authors find that learning the concept of energy has little lasting effect on students (Finegold and Trumper, 1989; Trumper, 1990a; Kruger et al., 1992). A possible strategy for improvement is to start with what children know and then modify their know- ledge. Ogborn (Ogborn, 1990; Boohan et al, 2001) notes that "we, like other animals, are built to pay attention to differences." He suggests that in developing the energy concept, we should make use of children's spontaneous thought by paying attention to perceived differences that drive processes.

Here, we present an extended and unified analysis of deep-rooted thought processes and show how they may be employed in teaching the energy concept. We shall demonstrate how hu- mans describe *generalized forces* such as pain, justice, imagination, light, heat, electricity, and many others. We commonly use image schemas that are projected metaphorically onto the ge- stalt of a phenomenon. The three most important schemas are those related to *intensity*, *quan- tity*, and *force* or *power*. Note that we do not use the term *force* in the sense of force in New- ton’s laws. Nor do we use the word *power* in terms of the physical concept power (as in the rate at which energy is released in a process). However, we will *associate* the schema of force or power with energy when creating theories of physical processes.

2. ENERGY AND THE FORCE DYNAMIC GESTALT

When children and adults speak spontaneously about physical processes, they do so in a form that reveals what we call the *Force Dynamic Gestalt* (FDG; Fuchs, 2007, 2010a). Cognitive linguistics (Lakoff and Johnson, 1999; Johnson, 1987; Talmy, 2000) shows that we base understanding upon certain schematic figures of thought that show up in language. Three of the most important are used to conceptualize natural, emotional, and social phenomena ranging from heat and light to pain and justice. The three schemas that form the basis of the FDG are quantity (size), quality (intensity and its differences), and force or power (see Fig. 1). (There are additional schemas that structure our understanding of forces such as balance, resistance, container, etc., which have been identified by Talmy (2000) in his theory of force dynamic structures of our language of causation.) These schemas are projected metaphorically onto a phenomenon in question (Fig. 2). We say, for example, (1) that there is heat in a room and that it can flow (metaphor: heat is a fluid substance), (2) that heat becomes more intense or that the temperature rises (metaphor: heat is a thermal landscape in which bodies move up and down or along a scale of hotness), and (3) that heat can be the cause of other processes (metaphor: heat is a powerful agent).

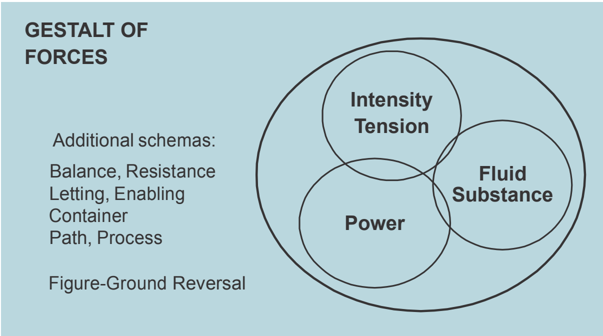

Figure 1. Schemas making up our conceptualization of a gestalt of forces (the Force Dynamic Gestalt, FDG).

Different phenomena (forces such as heat or electricity or others) are structured metaphorically using the same set of schemas (Fig. 2). This makes phenomena that do not have anything in common objectively similar to the human mind. As a result we see them as analogous and we can apply analogical reasoning. Note that metaphors are uni-directional projections whereas analogies are bi-directional.

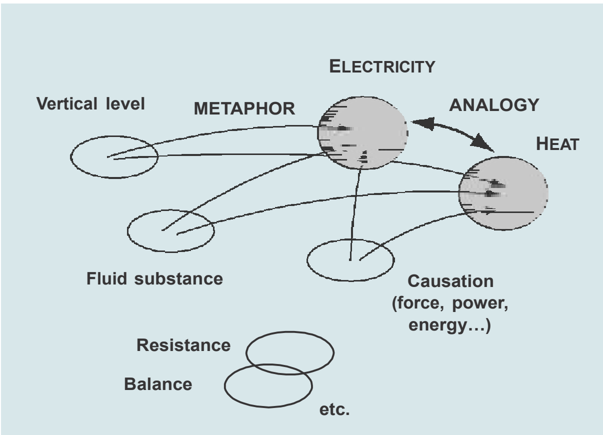

Figure 2. Metaphoric projection of schemas onto the target domain of a phenomenon. If the same schemas are used to metaphorically structure different targets, these domains become similar to the human mind which allows for analogical reasoning to be used.

We consider the third of these schematic aspects—*force* or *power*—the source of our notions of *energy*. Note that we do not have to use the word energy when speaking about it. This is certainly true for children, but also for adults. If we want to understand the energy principle as growing from the aspect of the power of a natural phenomenon, we need to learn about the schemas of fluid substance, (vertical) scale and its differences, and direct manipulation. We need to understand how the three are distinct and related (for example, the power of heat is proportional to a quantity of heat falling through a difference of temperatures, and proportional to this difference; this is Sadi Carnot's explanation of the power of heat in heat engines, see Fig. 3 and Fuchs, 2010b). This goal can be best achieved in early education by making use of well crafted stories that employ the power of schematic structures identified in narrative thought (Fuchs, 2010a).

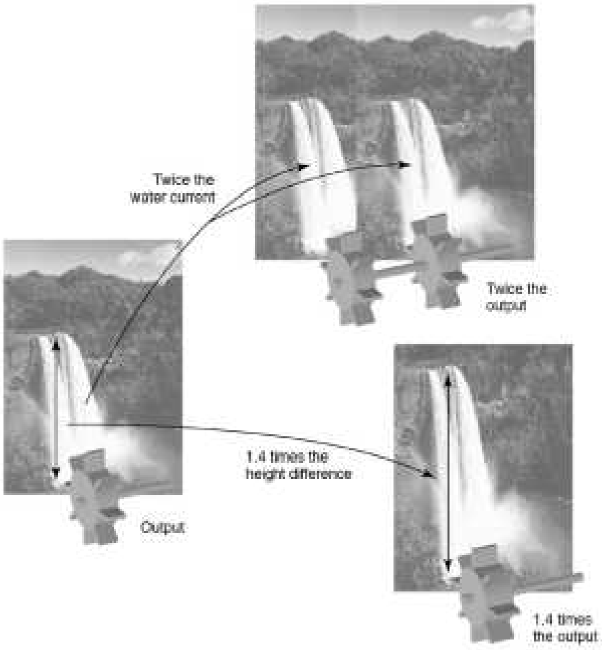

Figure 3. Sadi Carnot's image of the power of heat engines in analogy to the power of a waterfall.

It has been demonstrated that the conceptualizations used in macroscopic physics follow the structure of the FDG (Fuchs, 2007, 2010b). Processes are described as the result of the storage, flow, and production of fluid-like quantities (amount of substance, momentum, charge, entropy…). Transports, production, and storage are related to differences of intensive quantities (chemical potential, velocity, electric potential, temperature…), and the power of a process is determined as the product of current and potential difference. Therefore, we can construct the scientific concept of energy starting in early childhood if we nurture these everyday figurative conceptualizations that are, at the same time, the schematic structures of a formal science. By stressing the utility of every-day thought we do not mean to oversimplify a difficult subject, or to adopt a naïve view of understanding of nature. Rather, we want to let human thought evolve naturally using its own strength. Clearly, a teacher-training program based on the concept of the FDG can further this goal.

3. INTRODUCING TEACHERS TO THE ENERGY CONCEPT

Teachers have to be comfortable with their understanding of a principle before they can teach it confidently. We believe that if they know the foundations of a child's language concerning natural processes—which are the foundations of their own language as well—they will be in a position to be self-confident and creative in their teaching.

Here is an example of the use of everyday language that reflects the FDG and shows how the energy concept can be developed. Consider a watermill using the fall of water to grind flour. The story starts with a tension in the form of a height difference through which water can fall. This drives the millwheel and the millstone. The power of the water is quantified in terms of amount of water and height difference. The millstone (runner stone) turns relative to the stationary bedstone and the wheat between. Because of friction, the runner stone communicates its spin to the stationary stone and from there to the earth. At the same time, wheat is ground and some heat produced. Note that there is a tension, a speed difference, between the two stones, and we can introduce the notion of power of the rotational process. In summary, the falling water causes the millstone to turn which causes the grain to become flour and heat to be produced. Viewed from a different angle, two differences or tensions are produced in the course of the processes: grain versus flour and the temperature of the stones relative to that of the environment.

So far, the word ‘energy’ has not been used. We need this concept if we try to interpret the processes quantitatively through relations between amounts and differences. We can say that the falling water releases energy at a rate determined by the power of the process which depends upon the flow of water and the height of its fall. As the spin drops from the fast spinning runner stone to the stationary bedstone, it releases energy at the rate which is the power of the rotational process, and the energy released is used to produce flour and heat. Additionally, we see the energy released by the falling water as being transported to the waterfall, and the energy communicated from the water to the millwheel as being passed on to the millstones and finally to the flour and the heat that are produced.

The example of the description provided here can be transformed graphically using so-called process diagrams (Fuchs, 2010b, Chapter 2). To see this let us discuss a second example, that of heat driving an electric water pump (Fig. 4). If we have two bodies of water or any other material available—one hot, the other cold—we can operate a Peltier device in thermoelectric generator mode between the bot and the cold reservoirs. The Peltier device, in turn, drives the water pump.

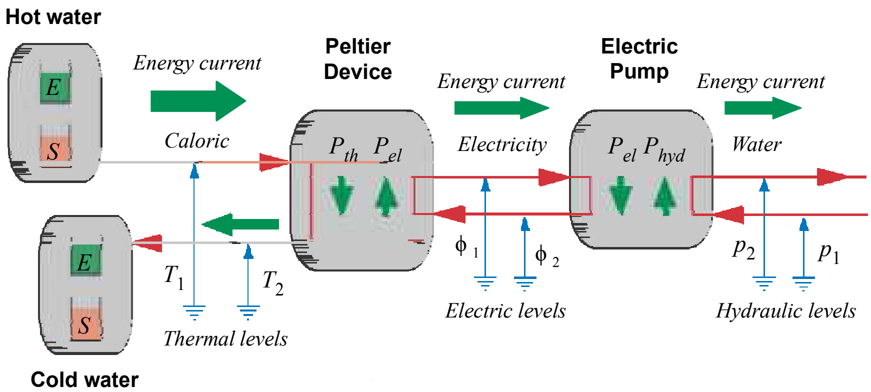

Figure 4. Process diagram representation of the chain of devices and processes leading from two bodies of water at different temperatures through a Peltier generator to an electric water pump. Fluidlike quantities representing the quantitative aspect of the FDG either fall or are pumped uphill and flow from device to device. Energy provides the coupling between processes in a device and the chaining of devices. Energy being released or used or flowing is represented by the green fat arrows. *P* denotes the power of a process.

The description goes as follows. Since the hot body of water gets colder in the process, and the colder one gets warmer, we interpret this as meaning that heat (caloric in Sadi Carnot’s sense) flows from the warmer to the colder body (see the left of the diagram in Fig. 4). It flows downhill from a warm place to a cold place. In other words, we interpret the temperature as the thermal level or potential. Heat falling from a higher to a lower level releases energy at a certain rate which is used by the Peltier device to pump electricity (electric charge) uphill (from lower to higher electric potential; see the central part in Fig. 4). The energy used to pump the electricity is passed on by electricity to the electric pump where it is released; note that the electricity flows downhill—from the higher to the lower electric level—in the pump. The energy released is then used by the pump to pump water which means that the pressure of the liquid is raised from a low to a high value (right side of Fig. 4). Finally, the energy used for pumping the water is transferred with the water.

We can use the idea of *differences* or *tensions* that has played such an important role in the previous examples as a fundamental descriptive tool. For example, as the gravitational tension of the water decays, a new rotational tension is set up which itself decays to set up new thermal and chemical tensions (heat and flour are produced). The world turns on this principle: tensions beget tensions that beget tensions…

What we have seen here can be transformed into a general approach to studying phenomena and formalizing our ideas of natural processes. The steps are the following: i) description of a process as a whole using common language; ii) refinement of the language used, stressing quantities that play a role; iii) description of the process in terms of fluid-like quantities, potential differences and associated elementary concepts (current, resistance, capacitance, etc.); iv) interpretation in terms of cause-and-effect (without using the word ‘energy’); v) introduction of energy quantities and energy balances. This method is appropriate for introducing pre-service and in-service teachers to narrative forms of descriptions of nature (supported by role games, stories, outdoors activities, laboratory work, drawings, writings etc.) that are eventually transformed into formal accounts. Most importantly, it is well suited to increasing levels of formalization and sophistication (from a qualitative approach using common language, up to quantitative procedures using graphs, maps, or mathematical relations). An entire graphical language, called process diagrams, has been developed that is intermediate between verbal descriptions and mathematical formulations (see Fig. 4; Corni at al., 2009; Fuchs, 2010b; Herrmann, 1998).

4. SUMMARY

If we follow modern cognitive science in general and cognitive linguistics in particular, we are led to identify basic figurative structures of the human mind which are used to conceptualize natural, psychological, and social phenomena and processes. We have introduced the Force Dynamic Gestalt as the cognitive structure that projects the schemas of quality/intensity, substance/quantity, and force/power onto phenomena, leading to metaphors. Processes are viewed as resulting from the flow of fluid-like quantities through differences of intensities (potential differences). They are forced by other phenomena, and they themselves force other phenomena in a chain of causes and effect. Energy is introduced as the measure of force/power of a process; in other words, it quantifies the relationship between cause and effect. Conceptualizing phenomena in this manner allows for a didactic approach that naturally leads from affective forms of narrative accounts to ever more formal descriptions. Linguistic and graphical tools have been developed that make this approach not only simple but also natural. It helps build the self-confidence of in-service and pre-service teachers since natural language serves as the steppingstone into the world of science.

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SELF-DETERMINED LEARNING IN SCIENCE CLASSROOMS (GRADE 8) – AN EMPIRICAL STUDY

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Abstract: The research project on Self-Determined Learning (SDL) represents an empirically tested educational approach based on the Self-Determination Theory (Deci & Ryan, 1993; Ryan & Deci, 2000a; Ryan & Deci, 2002b) and on specific teaching strategies. According to this theory instruction at school should emphasize the experience of competence (e.g. differentiation of tasks), of autonomy (e.g. free choice of activity) and the feeling of social relatedness (e.g. cooperative learning). With respect to these guidelines teaching units in physics (basic electricity and energy), biology and the German language which aim to improve instruction by enhancing Self-Determined Learning and achievement were developed.

The quasi-experimental study follows a treatment-control group design. To get information about the achievement in physics, the students were tested three times per teaching unit (pre, post and follow-up test). Questionnaires with psychological constructs for both students and teachers were used in addition as well as interviews and feedback sheets.

Analyses show (Göhring, 2010) that for example the experience of autonomy is significantly higher within the treatment group in contrast to the control group. Concerning other motivational constructs and achievement, there are in part opposite effects regarding the different types of school.

Keywords: Self-Determined Learning, science classrooms, physics education, empirical study, energy

BACKGROUND, FRAMEWORK AND PURPOSE

The research project SDL (Self-Determined Learning) represents an empirically tested educational approach based on specific teaching strategies. Teaching units in physics (basic electricity and energy), biology and the German language which aim to improve instruction by enhancing self-determined learning and achievement were developed. In the following I mainly restrict to aspects concerning the teaching unit on energy. The main contents are: definition of energy, different forms of energy and their transformation, energy in foodstuff, and saving energy at home (Göhring, 2010; Göhring & Laukenmann, 2006).

Instruction at school should take into account that both; cognitive and motivational aspects are important to initiating and fostering successful learning processes. The concept of this study is mainly based on the Self-Determination Theory according to Deci and Ryan (1993; Ryan & Deci, 2000a; Ryan & Deci, 2002b). Three basic human needs are of interest: the need to feel competent, the need to be autonomous and the need for social relatedness. Instruction at school should focus on these aspects, for example by differentiating tasks, by encouraging free choice of partners and of duration of activities, and by cooperative learning.

On the basis of this theoretical background, five educational guidelines were defined. For each educational guideline two teaching strategies were formulated: autonomy of the students (student centred instruction; activation of students), competence (differentiation of tasks; feedback), social relatedness (cooperation; play-like activities), structure (structured instruction; structured material) and relevance (authentic tasks; transfer). These guidelines and strategies describe the SDL-approach which is aimed at designing instruction that is more effective and more motivationally oriented.

RATIONALE

Education in Europe aims to foster personal autonomy and the use of both cognitive and affective skills to solve problems with regard to life-long learning (Hößle, 2004). As we know, motivation and positive learning emotions facilitate self-regulated learning (Boekarts, Pintrich & Zeidner, 2000). Within the Self-Determination Theory, Ryan and Deci make distinctions not only between intrinsic and extrinsic motivation but also between different types of extrinsic motivation (external, introjected, identified and integrated regulation). They emphasize the importance of a shift from mainly extrinsic to more intrinsic forms of motivation: *Frankly speaking, because many of the tasks that educators want their students to perform are not inherently interesting or enjoyable, knowing how to promote more active and volitional (versus passive and controlling) forms of extrinsic motivation becomes an essential strategy for successful teaching.* (Ryan & Deci, 2000a, p. 55).

METHODS AND SAMPLE

Each teaching unit was divided into two instructional phases (Weinert, 1999). Teaching in the first phase was carried out according to the following characteristics: highly student-centred instruction, no grades (but individual feedback), tolerance of mistakes, consideration of students' experience in everyday-life and their everyday concepts, self-regulated, activity-oriented and autonomous learning with many experiments, and cooperative learning. After the students received individual feedback based on special tasks, the second and shorter phase of the SDL concept focused more on the correction of mistakes and on students' learning success assessed through different types of additional exercises.

To test the SDL approach, a quasi-experimental field study was conducted during the school year 2005/2006 in 15 physics classrooms in south-western Germany (8^{th} grade, about 400 students and 15 teachers). The classrooms belonged to both low- and middle-level secondary schools. Eight teachers applied the SDL instructional approach in their classes (treatment group). Seven other teachers taught their classes (control group) in their usual way. All teachers taught the same content with the same learning goals over a period of about 17 lessons on basic electricity plus 14 lessons on energy.

As measures of achievement, one pre-test measure as a control variable (covariate) and two post-test measures as dependent variables were used. The pre-test measure was a test of students' pre-knowledge in the topics of electricity and energy. The first post-test measure of achievement was a graded class test which was relevant to the students' school reports. About six weeks later, a follow-up test measured the sustainability of SDL instructional units.

In accordance with the pre/post design, psychometric data were collected (from both; students and teachers) before the first instructional unit (time 1), between the two units (time 2) and after the second unit (time 3). In addition to questionnaires, feedback sheets were collected and interviews were conducted.

RESULTS

Motivational Constructs

To test the effects of SDL treatment on motivational constructs, multivariate analyses were computed using the General Linear Model (GLM) Procedure of the statistical software SPSS. In the GLM the fixed factors group, time and school types were included. The answering scale for every item reached from 1 (complete disagreement) to 4 (complete agreement).

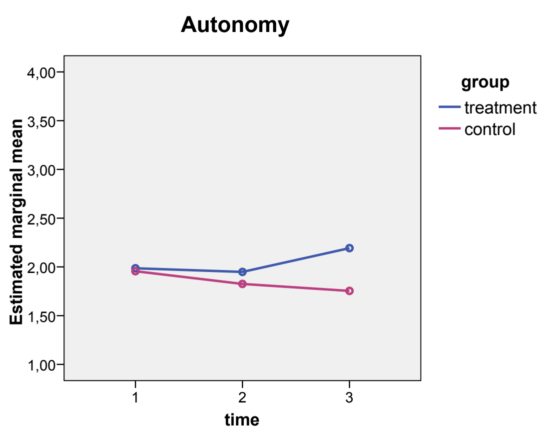

figure 1

Concerning the scale measuring Autonomy based on Röder and Kleines' (2003) autonomy scale (five items such as "In physics classes we can often choose between tasks on different levels"; $.65 \leq \alpha \leq .75$) a significant group effect was found (figure 1; $p < .001$, $eta^2 = .047$; $N = 330$). As intended with the concept, the treatment group felt more autonomous than the control group. Especially the second teaching unit on energy seemed to foster autonomy in classes quite well. Similar effects were found in low-level secondary school ($p = .011$; $eta^2 = .033$; $N = 136$) and in middle-level secondary school ($p < .001$; $eta^2 = .068$; $N = 194$).

Both scales measuring intrinsic motivation that is Interest Orientation and Competence Orientation (Lewalter, Schreyer, Wild, & Krapp, 1999) consisted of three items and showed good reliabilities ($.79 \leq \alpha \leq .87$; $.77 \leq \alpha \leq .87$).

Competence Orientation was ascertained with items like "Regarding physics I learn and take part in classes because it's important for me to improve my competence more and more". No significant group effect could be found for Competence Orientation but data showed an interaction time*group*school type ($p = .002$; $eta^2 = .019$; $N = 329$). While the treatment group showed a higher tendency of Competence Orientation than the control group in low-level secondary school ($N = 134$; n. s.), it was vice versa in middle-level secondary school ($p = .004$; $eta^2 = .029$; $N = 195$).

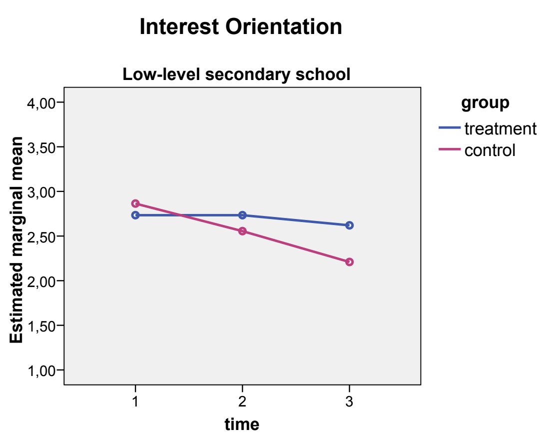

figure 2

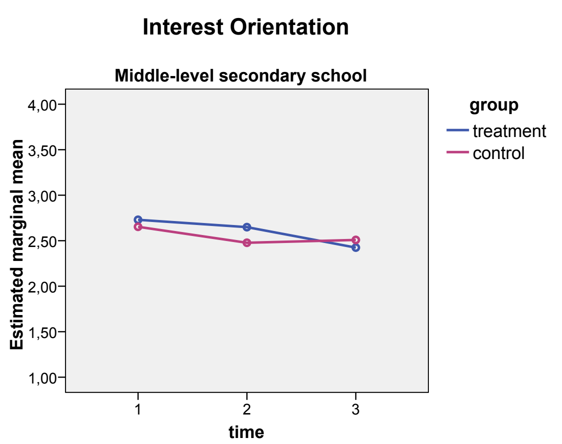

figure 3

“Regarding physics I learn and take part in classes because I’m very interested in the offered contents” was one of the items of Interest Orientation. Concerning this scale there was a significant group effect as expected ($p = .029$; $eta^2 = .011$; $N = 325$). Especially in low-level secondary school, SDL treatment was related to higher Interest Orientation (figure 2; $p < .001$; $eta^2 = .059$; $N = 133$). During the second teaching unit middle-level secondary school showed an opposite tendency again (figure 3; n. s.; $N = 192$).

Achievement

Regarding the development of achievement during the second teaching unit on energy, the General Linear Model (GLM) Procedure was computed again, this time multivariate with three covariates: class test and follow-up test of the first teaching unit and pre-test of the second teaching unit. All tests consisted of different kinds of tasks (reproduction, transfer, calculation) and the answering format was both prestructured and free.

In the graded class test on energy the students could obtain a maximum of 30 points. Concerning low-level secondary school ($N = 117$) the treatment group performed better than the control group (figure 4; middle-sized effect). In the follow-up test, with a maximum of 26 points to be obtained, the students of the treatment group did better on the test again, this time with a big effect-size (figure 5; $eta^2 = .259$). These results confirm the theoretical assumptions of Self-Determination Theory. As Self-Determined Learning is said to result in a better quality of learning it should foster achievement on the class test and especially the sustainability of learning on the follow-up test in this study.

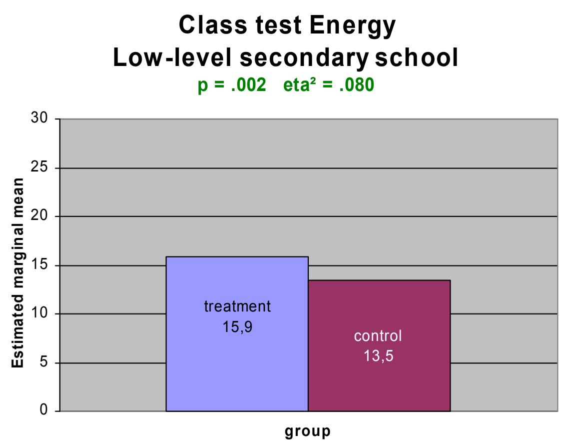

figure 4

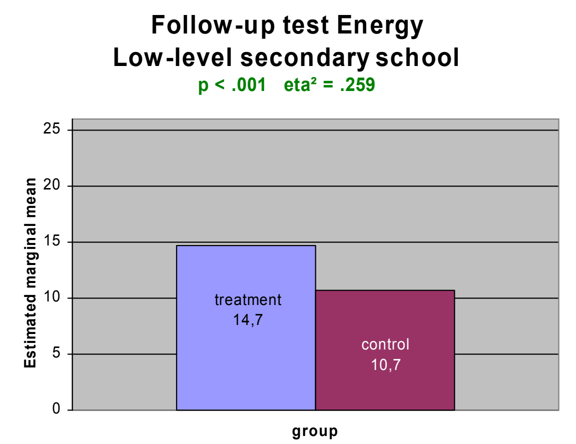

figure 5

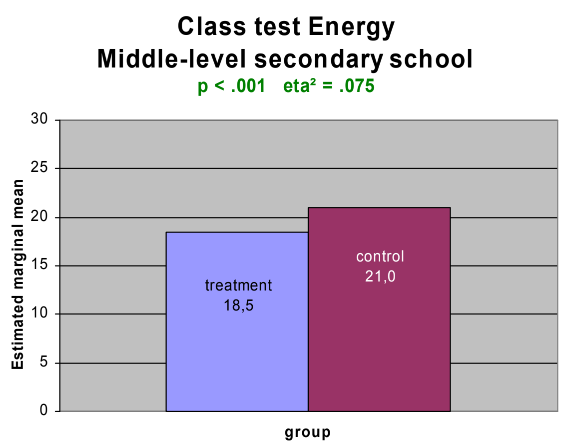

figure 6

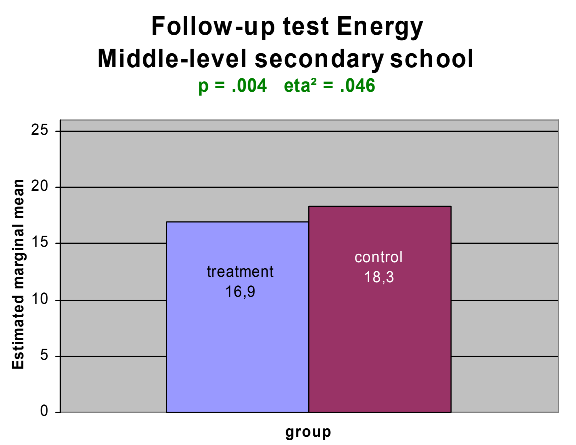

figure 7

Concerning middle-level secondary school (N = 182) unexpected results were found. There was also a middle-sized group effect in the class test, but the students of the control group performed better than the students of the treatment group (figure 6). A similar but low effect could be found in the follow-up test (figure 7).

Because of the unexpected results concerning achievement in middle level secondary school it made sense to pay attention to another scale of the students' questionnaire. With four items such as "Before a class test our teacher always says exactly what we should practice or repeat" the transparency of demands was rated by the students (using a modified scale originally developed by Ditton (2000); $.73 \leq \alpha \leq .77$). While there was no significant difference between the treatment and the control groups in low-level secondary school (figure 8; N = 137), the control group in middle-level secondary school showed a higher degree of Transparency than the treatment group (figure 9; $p = .001$; $eta^2 = .038$; N = 193). All teachers participating in the project were given the tests in advance but there were grounds for the assumption that especially the control group teachers in middle-level secondary school gave their students some extra training and more detailed information about the tests.

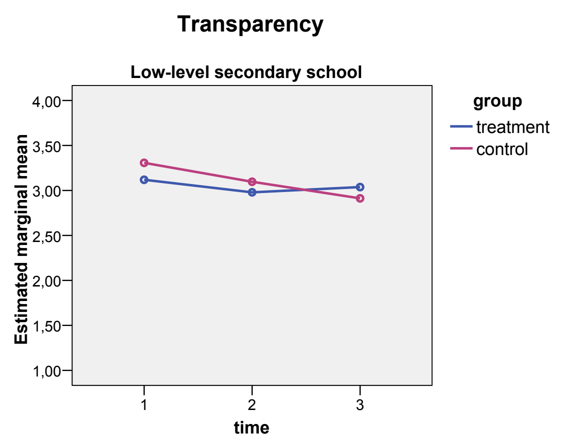

figure 8

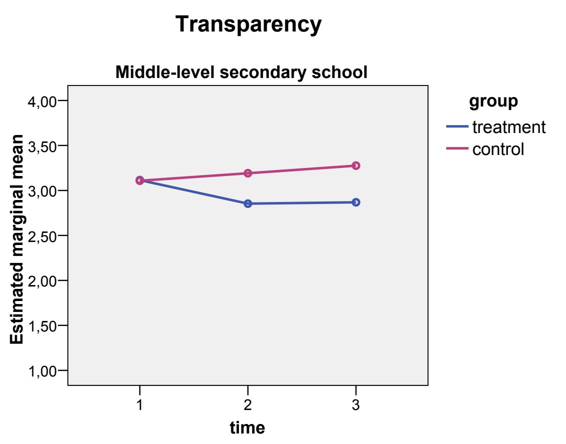

figure 9

Other indications might be the quality of intervention checked by the teachers' feedback sheets and investigations on class level. Some teachers of middle level secondary school didn't implement SDL concept as intended and one control class of middle-level secondary school was an outstanding high achiever class. For this reason it would have been better to have a sample of more than 7 or 8 classes of each school type or group.

Complex models

To evaluate the influence of different constructs on achievement regarding the second teaching unit on energy, analyses with Linear Structural Relationships (LISREL) were conducted. The overall model (figure 10) shows the relationship between different variables irrespective of the mode of group (treatment/control) or school type. Achievement on electricity was indicated by the class test and the follow-up test on electricity. Further independent variables were Transparency, Autonomy and Intrinsic Motivation (Competence Orientation, Interest Orientation), all measured to time 3 at the end of the teaching unit on energy. As to be seen on the left hand side of figure 10, the correlations between these variables are low and only in part significant; the assumption of independent constructs is thus justified. On the right hand side, the strong relationship (direct and indirect) between the achievement on electricity and the different measures of achievement on energy stands out.

Regarding the motivational constructs, a significant path to the sustainability of SDL instructional unit energy was only found from Intrinsic Motivation (0.14**). If the complex model is calculated separately for the treatment group, this path is 0.25** and the linear effect concerning the treatment group of low-level secondary school is even 0.45*** that is 20 % of the variance. Overall, one conclusion might be that achievement in physics is very stable and can hardly be influenced.

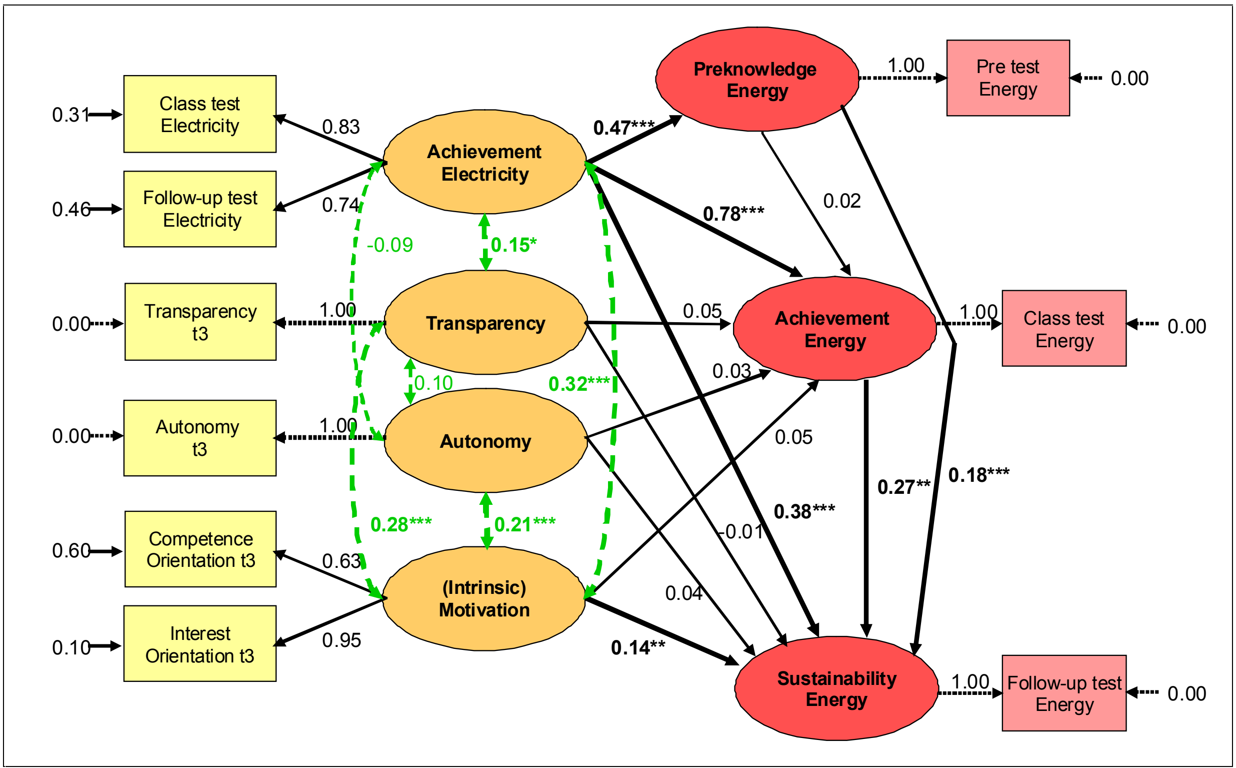

figure 10: LISREL model (total); Chi² = 14.84; df = 14; p = 0.389; RMSEA = 0.014; N = 288

CONCLUSIONS AND IMPLICATIONS

Analysis of the data shows interesting effects of SDL on motivational constructs and achievement (Göhring, 2010). Regarding low-level secondary school, SDL concept often has an effect as was expected, in contrast to middle-level secondary school treatment. Based on further analyses of the teachers' feedback sheets, the quality of intervention was not as intended in some classes of middle-level secondary school (e. g. less time, in part no experiments and cooperative learning). Furthermore, complex models (Linear Structural Relationships) show on one hand a significant path from Intrinsic Motivation to the sustainability of SDL instructional unit energy, but on the other hand the stability of achievement in physics. Greater variance concerning sustainability (energy) is explained by the achievement in electricity. Another reason for why motivational effects of the SDL treatment are lower than expected may be that motivation in the learning process is more closely related to personal aspects (e. g., teacher-student relationship; Gläser-Zikuda, Fuß, Laukenmann, Metz, & Randler, 2005) than to instructional methods. Thus an educational intervention focusing not only on instructional methods but also on the way of communication and interaction between teacher and students may be more successful in influencing students' motivation.

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THE INFLUENCE OF INTERCONNECTEDNESS AND PROBLEM-ORIENTATION ON ACHIEVEMENT IN CONTEXT-BASED LEARNING

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Abstract: Context-based learning is a widespread learning approach in German science teaching. Important features of this approach are the interconnectedness of context and chemical content as well as a focus on problem-orientation. Although it could already be shown that context-based learning has a positive influence on the interest of students, the results concerning their achievement are inconsistent. This could also be due to the lack of knowledge how to design a context to make chemical content clearer instead of more confusing. Hence, this project will investigate the influence of the above mentioned features, e.g. degree of interconnectedness and problem-orientation, on student achievement. Thus, self- learning texts were developed that vary according to these characteristics. Afterwards an intervention took place in which ninth-grade students worked on the self-learning texts. The study follows a pre-post-test design. The results of the pilot study show no significant difference in achievement for the different self-learning texts. However, results tend to show differences concerning the variable *problem-orientation* and its interaction with the variable *context* and *interconnectedness*. Therefore, the main study is conducted with a larger sample size and four self-learning texts for each student in autumn/winter 2011/2012 to confirm the results of the pilot study.

Keywords: context-based learning, problem-orientation, text learning

INTRODUCTION

Objectives

Context-based learning is a widespread and popular learning approach in chemistry education. Important characteristics of context-based learning are problem-orientation (Demuth, Gräsel, Parchmann, & Ralle, 2008) and the interconnectedness of everyday life contexts (e.g. food) with chemistry-related content (e.g. substances and their properties, conservation and changes) (Parchmann & Demuth, 2004; Parchmann et al., 2006). Studies show that context-based learning influences student interest and attitudes in a positive way (Bennett, Lubben, & Hogarth, 2007). Moreover, students in context-based learning environments also outperform their counterparts in traditional instruction under certain conditions (Fechner, 2009).

Based on this, the question arises why it is still necessary to investigate context-based learning. First, there are few studies and most of them struggle with methodological problems. For instance, they do not have a pre-post-test design, fail to eliminate confounding variables or do not randomize (Taasoobshirazi & Carr, 2008). Second, a high motivation or interest in the used contexts may not necessarily lead to higher achievement. Contexts, for example, can confuse the learner by activating irrelevant schemata which are closely related to the respective context but not to the chemistry-related content (Park & Lee, 2004). Third, it is not clarified which further context characteristics promote learning and how contexts have to be designed to make chemistry-related content clearer instead of more confusing (Park & Lee, 2004; Schwartz, 2006). Hence, the question is whether interconnectedness of context and content as well as problem-orientation, which are important characteristics of context-based learning as mentioned above, are also factors of influence on student achievement. For this reason, the following research questions will be investigated in this study on the basis of an experimental design:

RQ 1: Which influence does the degree of interconnectedness between chemistry-related content and everyday life context have on student achievement?

RQ 2: Which influence does problem-orientation have on student achievement?

RQ 3: If an interaction between problem-orientation and interconnectedness exists, of what kind is it?

RQ 4: Which influence on achievement is higher if the effects of problem-orientation and everyday life context are compared?

Theoretical Background

Apart from problem-orientation and interconnectedness, some other factors of influence on achievement can already be identified: Gomez, Pozo, and Sanz (1995) reveal that using different contexts causes different learning progress if the underlying content is the same. In addition, Song and Black (1991) demonstrate how the kind of learning task has an influence on learning progress. In their study, they use two different learning tasks (interpretation and application) and contexts (science and everyday life context). The combination interpretation task and everyday life context as well as application task and science context lead to the highest learning progress. A third factor of influence seems to be the personalization of learning tasks. A study by Son and Goldstone (2009) suggests that personalization affects learning, especially transfer.

METHODS

Study Design

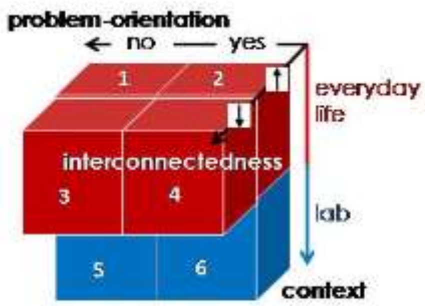
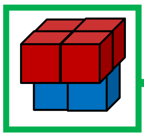


Figure1. The variation of the variables

Regarding the research questions, the study investigates three variables and their influence on achievement: context, problem-orientation and interconnectedness between context and chemistry-related content. To vary these characteristics, self-learning texts were developed in which these variables were realized. Each variable has two parameter values: high vs. low interconnectedness (RQ 1 & 3), problem-orientation vs. no problem-orientation (RQ 2 & 3) and everyday life context vs. laboratory context (RQ 4). In Figure 1, the three variables and their parameter values are presented. Each box represents one kind of self-learning text. Cell No. 1 for example, represents a non-problem-oriented, highly interconnected self-learning text, which is embedded in an everyday life context. Because of the fourth research question it was sufficient to develop self-learning texts that are embedded in a laboratory context and show only a high interconnectedness, as you can see in Figure 1 (RQ 4). Altogether, six different self-learning texts were designed based on the same chemistry-related content. To generalize results across different content areas, this variation of variables was accomplished for four different chemistry-related contents (e.g. *salts*) (see

Table 1). In summary, 24 (different contents*number of treatments; 4*6) self-learning texts were designed.

Table 1. The four chemistry-related content areas



	chemical content areas
1	salts I
2	salts II
3	acid & bases I
4	acid & bases II

The study employs a pre-post-test design. First, a pre-test is conducted, in which a content knowledge test is administered to students. Control variables like verbal ability and interest are also retrieved**.** Thereafter, the intervention proceeds and students work on the developed self-learning texts. Finally, a post-test follows using a content knowledge test and situational interest questionnaire (for an overview see Table 2).

Table 2. Test instruments

	control variables
pre	*interest questionnaire* (Fechner, 2009)
	verbal ability (one chart) (Heller & Perleth, 2000)
	dependent variables
pre & post	*content knowledge test* consisting of reproduction and application items; topics: acids & bases and salts (according to Koelbach, unpublished)
post	*situational interest* (Fechner, 2009)

Pilot study

To evaluate our test instruments, a pilot study was conducted in winter 2010/2011. In this study content area number 3 (see Table 1) was tested because no evaluated achievement test was available here. An overall number of 190 students (approximately 30 students per cell) participated. Students attended the 9th grade of an upper secondary school (Gymnasium). Two lessons á 45 minutes were necessary to conduct the study. During the first appointment, a test on prior knowledge (content knowledge test) and verbal ability was administered. The second time, interest data was collected and the intervention proceeded. Afterwards, the students had to fill in the content knowledge test and a situational interest questionnaire.

VARIATION OF VARIABLES

To vary the self-learning texts systematically concerning the three different variables, all self-learning texts consist of chemistry-related and contextual statements. The chemistry-related statements are sub-divided into concrete and general statements. Table 3 provides examples for the different types of statements.

*Table 2***.** Types of statements in a developed text

chemistry-related statements		contextual statement
general statement	**concrete statement**	
Salt dissolves in water because it is polar.	Potassium nitrate dissolves in the ground water because it is polar.	Fertilizer could dissolve in the ground water and transported by rain to a close swimming lake, because it is a salt mixture.

Variable *interconnectedness*

Self-learning texts are developed with either a high or a low degree of interconnectedness. High interconnectedness implies a high connection between context (e.g. *pollution of a lake)* and the chemistry-related content area whereas lowly interconnected self-learning texts show a low connection between those two aspects. For both types of self-learning texts, the general statements are the same, whereas the concrete and contextual statements are varied (see Table 4). If there is a low degree of interconnectedness, neither contextual words are embedded in chemistry-related statements (see last row/middle column) nor are chemistry-related words embedded in contextual statements.

Table 3. The variation of the variable *interconnectedness*

	chemistry-related statements		contextual statements
	general statements	**concrete statements**	
high interconnectedness	Salt dissolves in water because it is polar.	*Fertilizer* dissolves in the *ground water* because it is polar.	The fertilizer could dissolve in the ground water and transported by rain to a close swimming lake, *because it is a salt mixture.*
low interconnectedness		*The mixture* dissolves in *water* because it is polar.	The fertilizer could dissolve in the ground water and transported by rain to a close swimming lake.

Variable *problem-orientation*

In addition, self-learning texts were developed with and without problem-orientation. Problem-oriented self-learning texts start with a problem and explain it with the help of the content.

Table 4. The variation of the variable problem-orientation

	problem-orientation	no problem-orientation
order of statements	contextual statements	-
	problem	presentation of the content
	concrete statements	general statements
	general statements	concrete statements
	-	contextual statements

Without problem-orientation the self-learning texts start with the content and use the context as an application at the end of the text. Both self-learning texts consist of contextual and general as well as concrete chemistry-related statements (for an example see Table 5). The difference can be found in the sequence of statements: Problem-oriented self-learning texts present concrete statements before the general statements follow. In non-problem-oriented texts it is vice versa.

The variable *context*

Moreover, the variable *context* has two parameter values: everyday life and laboratory context. The resulting texts differ concerning their contextual and concrete statements. To make the texts comparable, almost the same amount of words and a similar sentence structure was used for the contextual statements. Concrete statements differ only in words. For instance, in self-learning texts, which are embedded in an everyday life context, the word *fertilizer* is used. In comparison, self-learning texts, which are embedded in a laboratory context, the word *chemical* is used instead of *fertilizer*. Each of the content areas is embedded in two contexts, meaning everyday life and laboratory. Table 6 presents the used contents areas and their contexts.

Table 5. The content areas and contexts

chemical content areas	contexts	
	everyday life	laboratory
salts I	pollution of a lake	analysis of idodide
salts II	polluted drink water	colour of a salt solution
acid & bases I	heartburn	disposal of a solution
acid & bases II	teeth & juice	identification of a solution

RESULTS

The results presented in this section refer to the conducted pilot study (content area 3).

As shown in Table 7, the total scale of the achievement post-test shows good internal consistency. Considering the subscales, differences in the internal consistency can be noticed. This probably depends on the amount of items. Thus, for the main study more application items have been constructed to raise internal consistency.

Table 7. Test parameters of different content knowledge measures (description, internal consistency estimate and number of items)

content knowledge post-test	description	α	Items
total scale		.931	36
recall	recalling uncontextualized facts or concepts	.900	24
application-inside the subject	narrow transfer of facts and concepts	.763	5
application-everyday life	applying concepts to unknown problems in the *real world*	.511	3
application-laboratory	applying concepts to unknown problems in the *laboratory*	.611	4

Concerning the learning gains induced by the texts, a paired *t*-test was conducted to determine whether the increase in learning caused by the texts was significant. It reveals that achievement increased significantly for all students ($t(185) = 11,863$; $p < .001$).

An ANOVA was used to test the influence of context (laboratory or everyday life), problem-orientation (yes/ no) and interconnectedness (high/low) on achievement. With reference to the whole sample, the results show no significant difference in achievement for the different self-learning texts (p = n.s.). Considering sub-groups, female students have the highest achievement in application items for highly connected, problem-oriented self-learning texts ($F(1,54) = .110$; $p < 0.05$, *part.* $eta^2 = .086$) (RQ 3). There are also some interesting tendencies: Self-learning texts with problem-orientation tend to lead to higher achievement levels in application items (RQ 2). Additionally, problem-oriented self-learning texts may lead to a higher learning outcome if they show a high degree of interconnectedness (RQ 3). Furthermore, in problem-oriented self-learning texts - if embedded in an everyday life context instead of laboratory context - students tend to learn more.

CONCLUSION & IMPLICATIONS

As mentioned above, the overall sample does not show significant differences in achievement concerning the different variables. This may be caused by several reasons: First, the small sample size might be responsible and tendencies might be confirmed in the main study. Tendencies comprise differences concerning the variable *problem-orientation* and its interaction with the variable *context* and *interconnectedness* (see results). Second, the type of self-learning text may have an influence by not allowing a high variance. Third, it can be assumed that students are used to learn from texts in a traditional way (non-problem-oriented) because most textbooks are structured like this. Achievement results might be better if they get used to the problem-oriented text by repeatedly being exposed to it. In consequence, each student will work on four self-learning texts in the main-study.

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AUTHENTIC INQUIRY LEARNING: STUDENTS AND SCIENTISTS "ON EQUAL TERMS"

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Abstract: In many developed countries, science systems seek solutions to encounter the problems of traditional science curricula (e.g. lack of engagement by students, poor image of science). Inquiry learning at authentic study sites is a promising approach to address this issue. In the research and development project "Kids Participation in Research" (KiP), five scientists from the Faculty of Life Sciences, University of Vienna, invited ten science classes (~200 students, aged 11-17 years) to their research facilities to work collaboratively on their current research topics. By providing authentic learning environments for inquiry learning, KiP aims to enhance the students' scientific literacy. The working model in KiP relies on three main features: authenticity, inquiry learning and cooperation "on equal terms". The students work together with real scientists, in their authentic laboratories, on their current research questions. Moreover, they negotiate their understanding of scientific issues with the scientists' views, on equal terms. This focus on students' perspectives in the course of science learning is derived from the learning theory underlying the model of Educational Reconstruction. Scientific concepts and the concepts held by students are both viewed as constructs which are negotiated on equal terms in order to reconstruct scientific contents based on the students' perspectives. This is a prerequisite for effective science learning, and KiP strives to apply this rationale to a dynamic, authentic learning environment. This paper presents the working model of the KiP project and discusses the results of its evaluation based on data from the project's pilot phase.

Keywords: authentic science, scientific inquiry, student-scientist partnerships, scientific literacy, educational reconstruction

INTRODUCTION

The research and development project "Kids Participation in Research" (KiP) creates an authentic stage for students to encounter scientific research at the University of Vienna. Scientists from various fields (e.g. neurobiology, palynology, marine biology) invite school classes to their research facilities. KiP is being funded by the Austrian Federal Ministry of Science and Research as part of the program "Sparkling Science" (www.sparklingscience.at). This program is designed to sustainably improve the interface between the school system and universities in Austria. This attempt is not unique. In many developed countries, science systems seek solutions to encounter problems of traditional science curricula such as lack of engagement by students, poor image of science, and insufficient teacher competence. The goal is to promote the development of a citizenry of scientifically literate persons and inspire young students to choose a science-related career (Stockelmayer, Rennie, & Gilbert, 2010). Promising attempts to meet these ambitious aims include cooperation between schools and universities, with student-scientist-partnerships being one concrete form of such cooperation (e.g. Sadler, Burgin, McKinney, & Ponjuan, 2010; Roth, van Eijck, Hsu, Marshall, & Mazumder, 2009; Tytler, Symington, & Smith, 2011). Such science apprenticeship programs often see themselves as an alternative educational approach for science learning compared to an out-dated and less valid school science which fails to convey the nature of scientific concepts and research methods (Braund & Reiss, 2006; Stockelmayer, Rennie, & Gilbert,

2010). Instead, giving students authentic insights into science in the course of a research apprenticeship program is assumed to portray a much more realistic image of science. The meta-analysis of such learning environments carried out by Sadler and colleagues (2010) revealed many positive outcomes: Amongst others, knowledge about the Nature of Science (NoS) could be enhanced and students developed a greater confidence for doing science. But the authors also conclude that there is a lack of "finer grained analysis of specific programmatic features" (Sadler, Burgin, McKinney, & Ponjuan, 2010, p. 253) of these learning environments.
We would like to meet this demand in our work. In KiP we have developed a theory-based working model for student-scientist-partnerships. It is designed to improve the learning processes of students (and their teachers) in terms of their knowledge about the NoS and their scientific literacy. In a next step, we would like to gain a deeper understanding of the processes we launched by focusing on the effects of the specific features of the learning environment in KiP.

RATIONALE

The KiP working model relies on three main features: authenticity, inquiry learning and participative collaboration. Authenticity refers to the collaborative work with real scientists, in their authentic laboratories, on current research questions. The positive effects of this practice on students' understanding of scientific knowledge and methods have been reported by various authors (e.g. Sadler, Burgin, McKinney, & Ponjuan, 2010; Roth, van Eijck, Hsu, Marshall, & Mazumder, 2009; Tytler, Symington, & Smith, 2011). Within this mutual work, students get the chance to conduct their own research projects while being mentored by the scientists. Teachers and educational researchers are also part of this cooperation and have mainly supportive roles.
KiP goes beyond authenticity and inquiry learning to follow a participatory rationale. All KiP stakeholders are challenged to act on equal terms. We try to reach this ambitious aim by installing a respectful atmosphere in the project so that the beliefs and opinions of all stakeholders are taken seriously.
In this paper we focus especially on the evaluation of the third feature of KiP: the participatory rational. According to the learning theory for science contents underlying the model of Educational Reconstruction (Kattmann, Duit, Gropengießer, & Komorek, 1997; Kattmann, 2005, 2007), this egalitarian approach is expected to positively affect science learning by the students. The model of Educational Reconstruction was primarily introduced to develop science teaching curricula in school settings. Following a constructivist understanding of learning processes and knowledge production, scientific concepts and students' conceptions are both treated as constructs. They are negotiated on equal terms in order to develop curricula which improve science learning. The development of the curricula demands a reconstruction of scientific concepts based on students' perspectives. On the one hand, this process involves students' perspectives about a given science content. On the other hand, it includes broad information resources about the science content including research papers, textbook knowledge, references to the philosophy and history of science. This process reveals a science content which is much more enriched compared to abstract canonical concepts. It is assumed to bare the essences of a scientific content in a way that students are able to generate a deeper understanding of it.
The novelty in KiP is that it applies the rationale behind the model of Educational Reconstruction to dynamic, authentic learning environments. Reconstruction of scientific content is not the task of an educational researcher in advance of science lessons. Rather, this process should evolve "live" through the mutual work of and discourse between scientists,

students, teachers and accompanying educational researchers, all of whom are committed to collaboration on equal terms.
The evaluation of the working model in KiP is based on data from the 2008-2010 pilot phase in which five scientists from the Faculty of Life Sciences, University of Vienna, worked together with ten science classes – about 200 students aged 11-17 years and ten teachers.

RESEARCH QUESTIONS

The main research question of this paper is: Does the working model in KiP succeed in implementing authentic environments for inquiry learning that are beneficial for science learning?
The overriding research question is answered by referring to the following, more narrow questions: Are scientific concepts reconstructed by incorporating students' concepts? Are scientific concepts and students' concepts negotiated on equal terms in KiP?

CONTEXT AND DATA

One out of nine sub-projects in KiP was analysed. In this sub-project, known as NEURO-KiP, students from a secondary school in Vienna (10^{th} grade) together with the Department of Neurobiology and Cognitive Research at the University of Vienna (an assistant professor and his PhD student) investigated the spider *Cupiennius salei*, a model organism. Two teachers and educational researchers were also part of this cooperation.
The data for the present contribution were collected mainly by recording the dialogues between the stakeholders in NEURO-KiP at the meetings.

METHODS

The transcriptions of dialogues were analysed by qualitative content analyses based on research strategies derived from the model of Educational Reconstruction (Kattmann 2007). In a first step, the contents negotiated between the stakeholders in NEURO-KiP were categorized. Then, potential cognitive concepts underlying the students' and the scientists' statements were revealed by adopting a hermeneutic approach.
The results show that some sequences in the conversation were especially fruitful for the analysis: These were passages in which the students provided an incorrect answer to a scientist's question because of a lack of understanding or because the students didn't believe in the knowledge claims of the scientist and argued against it. These passages revealed different underlying concepts, and they provided enough material to substantiate these concepts. Finally, post-interviews with all stakeholders were used for communicative validation of the results.

PROCESS ANALYSIS

Before presenting the results of the process analysis it is useful to examine the NEURO-KiP framework: The professor suggested working on a specific experimental design that is currently being investigated at his department. The experiment focuses on the visual orientation of the spider *Cupiennius salei* – a spider inhabiting the rain forest in Central America. The scientists are interested in determining the criteria a spider uses in choosing a tree to climb on and ask the research question "What makes a tree 'attractive' for a spider?". This is examined in a behavioural choice experiment where two stimuli (black bars) – which represent trees and which differ in only one parameter – are presented to the spider. The stimulus to which the spider runs is then observed (see Figure 1). From the results of this experiment, inferences can be drawn on the functioning of the spider's visual orientation system.

Figure 1: Authentic, experimental design in the scientists' research field

It was the students' task in NEURO-KiP to work on this authentic experimental design. They developed and carried out their own experiments within this design to answer the research question. Throughout the project the practical work was accompanied by intensive discussions between the students and the scientists. The discourse was dominated by the students' problems in understanding and accepting the highly reduced experimental design of the scientists. This is evident in the following student statements during the process:

Student:	The problem that I see is whether the spider thinks that these black bars are trees. How can the scientists know that?
Student:	Did you try with a real tree?
Student:	We always assume that the spider perceives the stimuli as a tree where it can live. But maybe it only perceives them as a form, to which it runs because it seems to be interesting for the spider.
Student:	And how do you know now that the spiders which grow up in nature where totally different factors are present, a lot more trees and other things, that these spiders follow the same laws like the spiders in this box?

These statements demonstrate what the process analysis revealed: Students intensively questioned the external validity of the experiments in multiple ways. From their perspective, knowledge about the behaviour of the spider in the laboratory can't be transferred to the behaviour of the spider living in its natural habitat. The students apparently had major problems in understanding and accepting the scientific method of parameter reduction. Instead of installing a laboratory experiment with a highly reduced environmental stimulus rate, they first even suggested constructing a biotope in order to design an experimental environment closely resembling the natural habitat of the spider (rain forests). The students assumed that one can only gain knowledge about the behaviour of the spider if it is examined in its natural habitat. The scientists, in contrast, argued that it is only possible to gather definitive knowledge if the behaviour of the spider can be traced back to only one parameter. During the course of the cooperation process, it turned out that two very different models of the spider as an organism underlie the opposing concepts. These are mirrored in the suggested experimental designs to answer the research question the scientist posed: While the students think of the spider as an individual which can control its behaviour and probably has a free will to act, the scientists think of the spider as a machine-like organism which automatically reacts to sensory input.

In addressing the doubts of the students and their problems in understanding the scientific view, the scientists referred step by step to the extensive knowledge on which the current experimental work is based. This led to highly enriched science contents and uncovered nature of science aspects. An example: At the beginning the scientists only declared that it is important to reduce parameters in a scientific experiment in order to be able to interpret the data. During the process the scientists were called upon to illuminate the process by which parameters are chosen and reduced: The scientists therefore referred to their model of the spider and to the huge number of earlier experiments that justify reducing a tree to a bar.

RESULTS

With regard to the research questions raised by the present paper, the conclusion is that scientific constructs are reconstructed by the scientists depending on the students' concepts in NEURO-KiP. The scientists needed to introduce numerous references which were important for students to understand and accept the experimental design. These steps were triggered by student questions, by incorrect answers to questions posed by the scientists, by the students' articulation of doubts and, of course, by the scientists' ability to provide all this background information. Does that, however, also mean that students' and scientists' concepts were negotiated on equal terms? Only partly. On the one hand, students were free to articulate their thoughts even if it meant that they questioned a scientist's work. On the other hand, the concepts of both stakeholders were not treated equally. Students' considerations about the reasons for the spider's behavior were, for example, often classified as "false" and not as different conceptions.

CONCLUSIONS AND IMPLICATIONS

This work revealed that the model of Educational Reconstruction is very valuable for developing effective authentic environments for inquiry learning. It is also an appropriate approach for gathering knowledge about the cooperation processes taking place in these environments during educational research. Regarding the evaluation of the working model in KiP, the results show that many important criteria of the learning theory underlying the model of Educational Reconstruction were successfully installed "live" in the cooperation process in NEURO-KiP. At the same time, the KiP working model may lack a reflective element that yields information about students' and scientists' concepts *during* the cooperation process and that renders it visible during the cooperation. This would have helped to negotiate students' conceptions and scientific constructs on equal terms. The assumption, according to the model of Educational Reconstruction, is that in this case students would have gained an even deeper understanding of the nature of science.

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LADS IN PHYSICS CLASSES: INTERACTIONS BETWEEN MASCULINITIES AND LEARNING OPPORTUNITIES

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Abstract: We investigated the influence of certain configurations of masculinity in the development of Learning Opportunities in upper secondary school physics classes and – reciprocally – the influence of Learning Opportunities experienced by students in the process of producing resistance patterns, power relations and collaboration in a group of three lads in a room class. Research design was based on the dovetailing of a Social Theory of Gender's analytical framework with classroom observation of ethnographical perspective. Along one year, we Observed one entrants 'Grade 10 class from within the classroom along one year and only then conducted in depth analysis of audio and video recording of anyone specific activity, Tone that Simulates Scientific team's work;. This activity occupied it ran for six lessons for that class, early in the school that year. Such The microanalysis of one group during this activity enabled us to characterize common interactions among lads its components. The results indicate that the interactions occurred in the learning groups according to profiles of masculinity that figure among students and interfered with Learning Opportunities that they experienced. The interactions between the guys in the group analyzed, shaped the standards of strength, power relations and collaboration that have been modified by the intervention of the teacher.

Keywords: learning opportunities; investigation activities; interaction between masculinities; learning groups physics learning

BACKGROUND, FRAMEWORK, AND PURPOSE

We have developed a theoretical-methodological construct to identify and analyse aspects that are not explicit or not conscious in the social interactions in Physics classes. Here, in particular, we focus on aspects of these interactions that determine gender configurations, standards of resistance and internal disputes. This investigation shows that they occur in learning groups and bring implications for students' individual and collective learning. We gave priority to aspects of these interactions that are related to the processes of construction and internalization of masculinities and that exert influence, both in the classroom dynamics, as well as in the constitution of the social identities that are built up within teaching/learning context of school Physics. We have established the connection between these elements appealing to Connell's social theory of gender (1995) and to the interactional ethnography concept of *Learning Opportunities*.

According to interactional ethnography, *Learning Opportunities* are the situations in which the students construct and embody meanings by means of verbal and nonverbal communication in social speech constructed in the coexistence in the classroom (BLOOME & BAILEY, 1992; REX; STEADMAN & GRACIANO, 2006). From the point of view of the interactional ethnography, the knowledge, the practices and the actions are located outside of the thought of the individuals, each one of them appears in the interaction that occurs between these individuals (JORDAN & HENDERSON, 1995). The mapping of these interactions makes possible the identification of the configurations of the masculinities and of the *Learning Opportunities* that are configured in this environment.

Connell (1995) refers to masculinity as a position on gender relations which has an influence on a person’s practices and ways he relates to physical, personal and cultural experiences. Therefore, different masculinities might be manifested, even on one single individual.

Haenfler (2004) argues that hegemonic masculinity of western values and legitimizes particular competition, hierarchy, individualism, sexual prowess, body strength, rationality, emotional distance, domination and courage to take risks. Connell (1995) identifies the interaction between groups of men alternating between patterns of resistance, power relations and collaboration that are configured around four standards of masculinity: hegemony, subordination, complicity and marginalization.

The hegemony refers to the cultural dynamic in which one group wins and maintains its leadership position in social life, she secures the position of male domination and subordination of women. This is the essence of hegemonic masculinity.

The subordination refers to the inferior position of women and men's groups that are outside the circle of legitimation of hegemonic masculinity. Homosexuals are the most representative case, but groups that have symbolic similarities with the women also fall in these groups being taxed by an abusive vocabulary - "nerd" mama's boy, coward, "woman," among others. The marginalization refers to the way in which some individuals subordinate groups by race and social class factors external to the gender order, stand as representatives of hegemonic masculinity of the dominant group. The protest masculinity is characterized when the focus turns into anti-school attitudes, aggression, transgression, and, ultimately, into social violence.

The complicity to men in general guarantees the privileges acquired by the patriarchy. It allows the connection to the current hegemonic project, even if the rules are not adopted strictly hegemonic. In this group fall the men of reason.

In western culture, scientific knowledge is many times associated with male characteristics. Physics, for instance, is iconic of an ideal rationalism, much valued in the west. The relations between different individuals that are established within classroom are determined by the interactions between different masculinities, the individuals' relation with Physics and with school, other individual characteristics and their learning potential. In this coexistence, they negotiate actions, construct and internalize social meanings and identities. We understand that, in this encounter, the specific masculinities valued at a certain moment define *Learning Opportunities* in Physics. We consider that there is a reciprocal interference between masculinities configurations and *Learning Opportunities*. We investigate how the masculinity standards intervene on the elaboration of *Learning Opportunities* and how the *Learning Opportunities* that the pupils lived interfere in the producing process of resistance standards, power relations and collaboration in masculine groups in a classroom.

In this paper, we analyse the interactions lived deeply in a group of lads, looking for masculinities standards that they reveal individually, the relations that they establish between them by means of these masculinities and the *Learning Opportunities* built in this process.

METHODS

The university committee on ethics in research involving human beings approved the procedures we planned to observe during the conduction of this investigation. We made audio and video recordings of male and female students, but only those that agreed to voluntarily take part; their parents also manifested approval of research use and diffusion of these data.

Along one year we stayed within the classroom and observed 17 boys and 8 girls of one Grade 10 class in an upper secondary federal school (Grade 10 to 12). Based on these observations of ethnographic character, we conducted ethnographic microanalysis of audio and video recordings of one teaching sequence which occupied six lessons, early that year. In this teaching sequence, the class was arranged in 9 groups of three or four students each. The challenge for them was to investigate a natural phenomenon. We analysed data as in descriptive research: familiarity with individuals and class gained on the year-long observations helped us to analyse dominant characteristics of the way individuals and groups worked during these six lessons. Descriptions allowed new analyses of episodes that focused on: (a) the relation between pupils within a group; (b) the relation between the group and the activity; (c) the relation the group established with Physics; (d) the relation between the group and other context elements, such as teacher and other groups.

Data gathered conducted to (i) identification of common characteristics of boys involved in the learning situation; (ii) descriptive characterization of aspects that facilitate boys' action; (iii) descriptive characterization of aspects that inhibit boys' action; (iv) comparison between results obtained in steps 'ii' and 'iii' for different kinds of learning situations according to two points of view, that of configurations of masculinities and that of the *Learning Opportunities*. In this paper we produce analysis of a single group due to the characteristics of its components and the generalisability of its analysis. Each of the three lads in the group acted according to one of the different masculinity pattern conceived by Connell (1995). Consequently, by analysing their actions along the activity we could see differences on how they created *Learning Opportunities* along the way.

The group that stands out here are due to the different profiles of masculinity that make up the group dynamics and the learning opportunities of its members. The characterization presented below for each of the boys who make up the group you want to get to know the aspects of masculinity involved in these tensions and their influence on Learning Opportunities developed there.

Roger has intellectual prestige among the classmates for his knowledge assimilation capacity as regards concepts of Physics. He makes a point of expressing to his colleagues these abilities. For him Physics appears as intellectual activity upscale own geniuses. He strives to demonstrate autonomy in the Physics lessons, but also infringes the classroom rules and always disperses the attention of his colleagues. He does its best to be recognized as "brilliant student" among peers and some teachers, personifies the western hegemonic masculinity.

Nicholas faces deep difficulties and resistances in his relation with school. He has low achievement in Physics and little participation in the classroom tasks. For him, physics is a discipline of prestigious outside their universe of possibilities. It has characteristics of masculinity protest.

Thales has good academic performance in Physics. Tales show affinity with both the intellectual elaboration of ideas and with their systematization and improvement. He is disciplined, concentrated and engaged to school tasks, expresses empathy with physics as a rational activity guided by systematic procedures. He presents characteristics of masculinity of men of reason.

We analysed interactions between the three during a student-centred activity designed to pass on an idea of how a scientific team works. The activity challenges students to solve open-ended problems, thus requiring them to take decisions, investigate phenomena and establish some cooperation among themselves. The dynamics of the activity simulates an atmosphere of game and competition alternating moments of work in group with moment of collective discussions mediated by the teacher involving all groups.

RESULTS

The hegemonic masculinity appeared around the relationships that occurred within the group examined at the first class. Since the group began to work there was a tension between the domineering attitude of Roger and the immediate engagement of Nicholas and Thales on the activity. Roger tried to impose the leadership of the group and to subordinate the colleagues at his will, trying to sabotage the activity by disqualifying it as school task and diverting the attention of his colleagues. Thales and Nicholas were instigated by the activity, they insisted on carrying out the investigation and to cooperate between themselves to overcome the challenges posed by the teacher seeking the collaboration of Roger. The investigation and discovery of the phenomenon consisted of *Learning Opportunities* that two colleagues wanted to share.

Roger challenged the rules of the classroom and tried to impose its control and authority over their colleagues. Nicholas found it difficult to concentrate on investigation in the face of provocations from Roger. He reacted with a certain aggressiveness to calls for Roger (in some way he responded when provoked and was controlled by Roger), but at the same time, trying to convince him to engage in investigation.

Most of the time, Nicholas sought to remain engaged in the activity, but as he had no prospects for academic success at that school, that made him likely to seek prestige among colleagues by confronting the classroom rules and by challenging authority. He wanted to engage with the activity at different times, but Roger's influence dispersed him.

The relationship of Roger with Nicholas and Tales denoted hierarchical position, individualism and dominating rationality. Roger advised the group only on issues that required "intellectual work", but refused to make measurements or notes. He denied his colleagues' knowledge of and their explicit desire to engage in investigation, thus sharing *Learning Opportunities*.

In our interpretation, the authority granted to Roger occurred around their intellectual prestige, as evidenced by the domain that showed in relation to scientific knowledge. It was a rational strategy of the group to stay in front of the other groups in investigation. Evidence of this is the fact that the explanation developed by Roger to analyze the phenomenon was accepted with enthusiasm by Nicholas, since they could be at an advantage over other groups. This reinforced the arrogance and individualism of Roger that preferred to disregard the comments made by Nicholas and Tales inhibiting them, with explanations that take into account only their view and supposed prior knowledge.

Roger's relationship with his colleagues showed two patterns of masculinity. The first was the hegemonic standard of knowledge and rationality that led him to assist the group only on issues that required "intellectual work", but refused to make measurements or notes. However, he did not respect the opinions of their colleagues and their explicit desire to engage in investigation sharing *Learning Opportunities*, as they did the other groups. This compromised their performance in investigation and left the group at a disadvantage compared to others.

The second model of masculinity is close to what Connell (1995, 2000) identifies as "protest masculinity" linked to "complicity" between Roger and Nicholas (Connell, 1995). "Protest masculinity" is a way to gain prestige among peers, scoring differences and get pleasure by the confrontation with the rules and challenge authority. Nicholas had no other sources for academic success at that school, this made him likely to resort to "protest masculinity" as a means to gain prestige among colleagues. He wanted to engage with the activity at various times, but the influence of the demoted Roger. There was complicity between the two about the jokes and games in class. in this case, the trend is highlighted by Roger to challenge the rules in the room lesson and deter his group and other groups to focus on the task. Even when it was curious or intrigued by the phenomenon that Roger tried to shine the tasks was not to challenge him.

Thales sought alternatives for the group could carry out the activity; he made use of the rationality of Roger and the aid of Nicholas to carry out tasks without getting in conflict with them. That was his strategy to stay in investigation, in the running of the competition and develop new *Learning Opportunities*.

The collective discussions with the whole class allowed the socialization of investigation strategies and findings of the groups leaving all of them always at the same level, with the completion of a task that was available to everyone. The teacher's interventions in the groups encouraged them to organize more collaboratively and to share tasks. Both in the intervention in the small groups, as well as in collective discussions, the teacher tried to manage the tensions generated by the participation of boys like Roger inhibiting actions and relations of domination in favour of interactions guided by cooperation and dialogue with the ideas of colleagues.

CONCLUSIONS

We used interactional analysis to problematize configurations of masculinity and their influence on the elaboration of *Learning Opportunities* in a group of boys in a Physics classroom. The *Learning Opportunities* were focused in the living experience of the discovery process, the search for evidence to prove or rule out forecasts and assumptions, the discipline to carry out measures, the negotiation of expectations and the organization of a work plan.

By resorting to challenging situations, such as open investigation activities in the classroom we must keep in mind some care. Important dimensions of the training of lads are put at risk when - in a discipline such as physics - they are guided by Western hegemonic standard of masculinity, that legitimizes and values, for example, competition, an ultra-rational objectivity, individualism, emotional distance , domination, etc..

In this work, we gave special attention to the fact that a guy with a strong tendency towards individualism and great need to show himself superior enforced anti-school attitudes and indiscipline in another pupil with problems in school. However, tensions between different forms of masculinity were relieved when those involved were instigated by the activities in the classroom and saw possibilities of growth and success in the face of others colleagues or other masculinities. The collective discussions and the teacher's interventions gave priority to *Learning Opportunities* that forced configurations of masculinity based on partnership relations among group members.

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HOW ARE HIGH SCHOOL STUDENTS' EPISTEMOLOGICAL BELIEFS RELATED TO THEIR GOAL ORIENTATIONS?

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Abstract: Literature reveals that epistemological beliefs and goal orientations affect students' strategy use and learning in turn. When students set mastery goals they are expected to use more advance strategies such as elaboration and critical thinking and develop conceptual understanding. In order to support meaningful learning, the relationship between epistemological beliefs and goal orientations needed to be defined clearly. This study was conducted to examine the relationship between two sets of variables: epistemological belief (the belief that learning depends on effort, the belief that learning depends on ability, and the belief that truth can change) and goal orientation (performance approach, performance avoidance, mastery approach, and mastery avoidance). Epistemological beliefs were assessed with the Epistemological Belief Questionnaire while goal orientations were measured using the Goal Orientation Scale. The data were collected from 950 Turkish high school students participating chemistry classes. Results of canonical correlation analysis revealed one significant canonical variate pair (R_c^2 =. 37). The beliefs that learning depends on effort and ability were associated with performance approach and mastery approach goals.

Keywords: Epistemological beliefs, 2 x 2 achievement goal framework, chemistry, science education, canonical correlation analysis

INTRODUCTION

The purpose of this study was to examine the relationship between Turkish high school students' epistemological beliefs and goal orientations in chemistry courses. Recent studies revealed that students' epistemological beliefs are effective while they are setting learning goals (Ozkal, Tekkaya, Cakiroglu, & Sungur, 2009; Chen & Pajares, 2010). Students' who possess more sophisticated epistemological beliefs tend to set mastery type of goals more frequently and expected to use self-regulatory strategies more effectively (Ozkal et al., 2009; Chen & Pajares, 2010).

Achievement Goal Theory

Achievement Goal Theory explains the reasons for learning. Initial studies were guided by dichotomous (mastery versus performance goals) (Pintrich & DeGroot, 1990) or trichotomous frameworks (mastery, performance-approach and performance-avoidance goals) (Elliot & Church, 1997). Recently, Elliot and McGregor (2001) propsed a 2 x 2 achievement goal framework: performance approach, performance avoidance, mastery approach, and mastery avoidance. They developed a new instrument reflecting four goal orientation types and found empirical evidence. Mastery approach goals emphasize mastering the task or learning the task for its own sake and use achievement standards such as progress in the task or deep understanding of the topic. Mastery avoidance goals were defined as avoiding misunderstanding or not learning and students set not being wrong as a standard for learning. On the other hand, performance approach goals focus on doing better than others in a task and getting better grates than others is more important for learners. Lastly, students setting performance avoidance type of goals give importance to not looking stupid compared to others and not getting worse grades than them. Although the validity of 2 x 2 achievement goal framework is still discussed, a few studies are providing empirical support (Bartels & Magun-Jackson, 2009; Conroy & Elliot, 2004; Sungur & Senler, 2009). The present study was guided by the 2 x 2 achievement goal framework.

Epistemological Beliefs

Epistemology as a discipline tries to explain individuals' beliefs about the nature of knowledge and knowing. It is "an area of philosophy concerned with the nature and justification of human knowledge" (p.88, Hofer & Pintrich, 1997). The present study was guided by multidimensional models which suggest that epistemological beliefs are independent; in other words, students can hold more sophisticated beliefs in one dimension and more naive beliefs in another (Schommer, 1990; Hammer & Elby, 2002). In addition, in this study students' epistemological beliefs were defined based on the dimensions in the Schommer's questionnaire (Schommer, 1990) which reflects students' beliefs about knowledge and learning.

The Relationship between Students' Epistemological Beliefs and Goal Orientations

Recently researchers have been sought for the relationship between students' epistemological beliefs and goal orientation types and tried to understand mediating factors in learning. Their attempts to understand whether students possessing different epistemological beliefs tended to set specific type of goals and revealed more condense models (Ozkal et al., 2009; Chen & Pajares, 2010). For example, Chen and Pajares (2010) found that students holding more sophisticated epistemological beliefs tended to set task (mastery) goals while students with naïve perspective tended to set performance goals. They also found that students' motivational goals orientations affected their science achievement indirectly through self-efficacy.

Lately the effect of students' epistemological beliefs and goal orientations on different learning outcomes such as strategy use and self-efficacy beliefs has been investigated in the literature. Students using mastery goals are believed to employ higher order learning strategies such as elaboration more frequently. In order to develop classroom environments that support conceptual understanding and in turn increase achievement, initially the relationship between epistemological beliefs and goal orientations should be understood.

Research Question

The following research question guided the study: How strongly are Turkish high school students' epistemological belief variables related to their goal orientation types for chemistry context?

METHODOLOGY

Subjects of the Study

Totally 950 high school students attending chemistry courses participated in the present study. Of 950 students, 356 students (187 females, 169 males) were ninth graders, 323 (173 females, 148 males, and two nonrespondents) were tenth graders, and 271 (157 females, 112 males, and two nonrespondents) were eleventh graders.

Instruments

The Epistemological Belief Questionnaire (EBQ) developed by Schommer (1990) and adapted to Turkish culture by Deryakulu and Buyukozturk (2002) was administered to students to measure their epistemological beliefs. The Turkish version of the scale, showed a three dimensional factor structure: the belief of learning depends on effort (mentioned as *effort* throughout this study), the belief of learning depends on ability (mentioned as *ability*), and the belief that truth can change (mentioned as *truth*). In the present study, Confirmatory Factor Analysis (CFA) using LISREL 8.30 for Windows (Jöreskog & Sörbom, 1993) revealed the fit indices (.069 for Root Mean Square Error of Approximation (RMSEA), .073 for the Standardized Root Mean Square Residual (SRMR), .69 for Non-Normed Fit Index (NNFI) and .72 for Comparative Fit Index (CFI) were within acceptable limits, except for NNFI and CFI (Kline, 1998). The Cronbach alpha coefficients ranged from .48 to .71. Although the reliability coefficients were low, these values were close to the values reported in the literature (Schommer, 1993; Deryakulu & Buyukozturk, 2002).

The Goal Orientation Scale developed by Elliot and McGregor (2001) and translated to Turkish culture by Senler and Sungur (2007) was administered to determine the type of goals students pursue while studying for chemistry course. The instrument included four subscales: mastery approach, mastery avoidance, performance approach, and performance avoidance. Confirmatory Factor Analysis (CFA) was performed to test factorial validity of the scale. Findings indicated a good model fit with the following fit indices: RMSEA = .079, SRMR = .059, CFI = .95, and NNFI = .93 (Kline, 1998). The Cronbach alpha coefficients were found between .68 and .76.

RESULTS

The means and standard deviations for each factor, and bivariate correlations between the variables in each variable set and between the variable sets were presented in Table 1. High values for the mean scores indicated that students possess more sophisticated epistemological beliefs use that goal orientation type more frequently.

Table 1

Means, standard deviations, and bivariate correlations among measured variables in two variable sets.

Subscale	1	2	3	4	5	6	7
1. Effort	1.00						
2. Unchanging Truth	-.19**	1.00					
3. Ability	.17**	.17**	1.00				
4. Performance approach	.19**	-.19**	-.02	1.00			
5. Performance avoidance	.03	-.22**	-.14**	.49**	1.00		
6. Mastery approach	.32**	-.13**	.18**	.33**	.10**	1.00	
7. Mastery avoidance	.05	-.17**	-.13**	.25**	.33**	.21**	1.00
Mean	3.92	2.83	3.53	3.72	3.24	4.19	3.21
Sta. Dev.	.39	.51	.66	.97	1.06	.80	.97

**. Correlation is significant at the .01 level (2-tailed).

The canonical correlation analysis (CCA) was conducted to test the relationship between two variable sets (epistemological belief and goal orientation variables). Results of CCA revealed three canonical variate pairs; however, only the first canonical variate pair was found to be significant. The canonical correlation coefficient between two canonical variates was found to be .37 accounting for 14% of overlapping variance.

Table 2 summarizes the correlations, standardized canonical coefficients, canonical correlations, percentage of variance, and redundancies between epistemological belief and goal orientation variables for the first canonical variate pair. Explained variance by epistemological belief and by goal orientation were 29% and 39%, respectively. When the canonical loadings were examined, the values greater than .40 were accepted as meaningful (Weiss, 1972). Effort and ability positively correlated with the first canonical variate while only the approach type of goals made significant contribution to the second canonical variate. Effort accounted for the highest percentage of variance with a loading of .90, whereas mastery approach goals has the highest with a value of r=.95. Truth and avoidance type goals did not have any significant contribution. On the other hand, the amount of variance in the canonical variate explained by the other canonical variate (called the redundancy index) was 4% for the epistemological belief and 6% for the goal orientation.

Table 2

Correlations, standardized canonical coefficients, canonical correlations, percentage of variance and redundancies between epistemological belief and goal orientation variables

	First Canonical Variate	
	Correlations	Coefficients
Epistemological beliefs variables		
Effort	0.90	0.78
Unchanging Truth	-0.30	-0.22
Ability	0.53	0.44
Percentage of variance	0.29	
Redundancy	0.04	
Goal orientation variables		
Performance approach	0.49	0.31
Performance avoidance	0.03	-0.16
Mastery approach	0.95	0.90
Mastery avoidance	0.04	-0.17
Percentage of variance	0.39	
Redundancy	0.06	
Canonical correlation	0.37	

DISCUSSION AND IMPLICATIONS

In this study, the relationship between Turkish high school students' epistemological beliefs and goal orientations was investigated. The results revealed that the canonical correlation between two variable sets accounted for 14% of the overlapping variance. In addition, the goal orientation variate accounted for higher variance (39%) than the epistemological belief variate (29 %). The beliefs that learning depends on effort and ability were associated with performance approach and mastery approach goals. This indicated that students who possessed more sophisticated epistemological beliefs, set approach type of goals more frequently while studying for chemistry course. Accordingly, explicit instruction of nature of science can help students develop more sophisticated beliefs and increase chemistry achievement in turn.

Mastery approach goals found to be explaining the highest variance of the canonical variate goal orientation with a canonical correlation value of r=.95. This result is parallel with the previous studies (Ozkal et al., 2009; Chen & Pajares, 2010). However, performance approach goals were also found to be positively correlated to epistemological beliefs which mean that students holding more sophisticated epistemological beliefs tend to set these goals as well as mastery goals. In Turkey, students are required to take nationwide exams in transition to a higher education level. Taking high scores from these exams are important to attend high reputation schools. Therefore, students might set performance goals for themselves to be more successful than other students.

This study has implications for educators and future research. Teachers should emphasize meaningful learning and help students develop sophisticated epistemological views. This study focused more on the relations between two variable sets in chemistry course for high school students in Turkish context. In the further studies, structural equation models can be employed to test the direct and indirect paths between these variables, and their relationship to academic achievement.

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A study on the relationship among the cognitive, emotional and social development of Open University Students.

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Abstract: This study focuses on the investigation of the relationship among the learning outcomes, the emotional experiences and the social interactions of students in a distance education setting in Greece. The present study involved 153 postgraduate and undergraduate students enrolled in distance learning courses at the Hellenic Open University. Questionnaires were used as a data collection instrument for the survey and the data were analyzed using Statistical Package for Social Sciences (SPSS). The analysis of the data gathered provided evidence regarding the correlation among the three variables used in our research. Findings indicated that the learning outcomes have little or no relation either to the emotions of students or to the social climate. In addition, the results revealed that the social climate and the emotional experiences of students are closely related.

Keywords: distance learning; cognitive development; emotions; collaborative learning

INTRODUCTION

Within only a few years, distance education emerged as a new philosophy for knowledge transmission offering new and flexible learning opportunities that overcome the restrictions of time and space. Over the years, the demand for distance education courses has grown exponentially as people seek for new and flexible ways to update their skills while they meet the demands of their busy lifestyles.

Rationale

Distance education is "a practice in which the learner and the instructor are separated in space and/or time" (Saba, 2005:262). Distance learning programs are designed to be carried out by technology that allows learners to attend online lessons according to their schedule, have access to the educational material and communicate with the instructor and the other learners.

Although distance education provides the flexibility of combining studies with work and family obligations, it demands more responsibility from the learners. Distance learners are independent, autonomous, self-motivated and managers of their own time (Berge, 2007; Shih et al., 2008). They built their knowledge on their own while the use of technology enhances their critical thinking, research and problem-solving skills (Bedard & Knox-Pipes, 2006; Berge, 2007; Lunney et al., 2008).

For an effective learning environment in both distance and traditional settings social interaction is an essential component. As Pauls (2003:3) argued "it is not the location of education that determines the effectiveness, but the amount on transaction between the learner and the instructor".

Learning is a social process and therefore, the development of social climate is a key factor for high levels of academic performance (Koh & Hill, 2009; Kreijns et al., 2004). Learner-learner and teacher-learner interaction will allow the exchange of information, ideas and collaborative learning. Additionally, distance education programs must meet the requirements of today's workplace for highly skilled personnel with communication and collaboration skills, problem-solving and decision making skills. Although social interaction is a significant area for education, it's affect on learning in distance education settings has been neglected by research (Oren et al, 2002).

Another basic factor related to the academic performance of students is emotions. Due to the lack of physical presence students experience emotions of isolation and lack of community sense in distance learning settings. Until recently, the role of emotions and their impact on the learning performance of students has been a neglected topic to the research agenda, with the exception of test anxiety (Pekrun, 2005). However, in the last few years, the research has highlighted that emotions are an integral part of education and affect student's motivation and engagement in the learning process (O' Regan, 2003; Op't Eynde & Turner, 2006; Wosnitza & Volet, 2005).

In Greece, research in the field of distance education developed substantially with the foundation of the Hellenic Open University that dates back to 1992. Although several subjects have been examined including student's perceptions about distance education, student-dropout and economical issues, there is limited theoretical framework as the majority of the published research focuses on the evaluation of the educational material (Giosos et al., 2008).

The aim of the current study was to investigate whether student's emotional experiences and the development of social climate in the distance education setting of the HOU have an impact on student's learning outcomes.

METHODOLOGY

Objectives of the study and research question

The main purpose of this study was to investigate the emotional experiences of students and relate them to the social climate and to the learning outcomes. Student learning outcomes (SLO) are defined in terms of knowledge and skills gained as a result of participating in a particular set of educational experiences (Montgomery College, 2009). The aim of this study was to answer the following research question:

What is the relationship between the learning outcomes, the emotion of students and the social climate in the distance education environment of the Hellenic Open University?

Procedure

A questionnaire based on the Learner Questionnaire (LQ), which was used by the Australian Council for Educational Research-ACER, was designed as an instrument for gathering data on students' perceptions relative to the distance education provided by the HOU. The aim of the questionnaire was to investigate cognitive, emotional and social aspects and the relationship among them.

The questionnaire was divided into two sections. The first section consisted of closed quantitative Likert-type questions. The items were ranked according to a 1 to 5 Likert scale (strongly agree, agree, neutral, disagree, and strongly disagree). The second part of the questionnaire aimed to deal with demographic data (e.g. gender, age, year of study, program of study). The instrument was administered face-to-face to the distance learners during the face-to-face meetings.

Participants

The participants of this study consisted of 153 postgraduate and undergraduate students of the HOU. Of the participants 57% (n=87) were female and 43% (n=66) were male. The participants' age ranged to three categories: ninety five students were over 33, forty nine students were between 28 and 32 and nine students were between 23 and 27.

Results

Data gathered from the questionnaire were organized and analyzed using Statistical Package for Social Sciences-SPSS. Since we presumed correlated factors, a direct oblimin rotation was selected and five factors were extracted. These five factors explain 50% of the total variance, which is a high percentage for social science standards. Therefore we can assume that the extracted factors successfully summarize the 36 variables used in the analysis. The five factors that were extracted were:

1. Satisfaction with the trainers and the lessons
2. Anxiety, insecurity and boredom
3. Gain of skills and knowledge
4. Poor facilities and organization and
5. Generic disappointment

Examining the correlations between the five factors extracted can give an indication of the relationship between the emotions of the students and the skills they gained (see figure 1).

	Factor 1: Satisfaction with the trainers and the lessons	Factor 2: Anxiety, insecurity, boredom	Factor 3: Gain of skills and knowledge	Factor 4: Poor facilities and organisation	Factor 5: Generic disappointment
Factor 1: Satisfaction with the trainers and the lessons	1	0.021	0.111	-0.302**	-0.421**
Factor 2: Anxiety, insecurity, boredom	0.021	1	-0.044	-0.034	-0.062
Factor 3: Gain of skills and knowledge	0.111	-0.044	1	-0.120	-0.155
Factor 4: Poor facilities and organisation	-0.302**	-0.034	-0.120	1	0.250**
Factor 5: Generic disap-pointment	-0.421**	-0.062	-0.155	0.250**	1

**. Correlation is significant at the 0.01 level (2-tailed)

Fig1: Pearson correlations among the five factors

As showed in figure 1 the third factor, which is an expression of the skills and knowledge gained, is not correlated to any kind of emotions. On the other hand, we do see some significant correlations between the different emotions: it seems that those who are satisfied with the trainers and the lessons are less likely to express a generic feeling of disappointment (-0.421) or to claim that the facilities and organization of the HOU are poor (-0.302). The results of the survey also revealed that there is a positive correlation between factors four and five (0.250), indicating that the feeling of generic disappointment is caused partially from the poor facilities and organization of the HOU.

According to figure 2 the results indicated that the most significant problem respondents faced when doing group work was the lack of time, nearly 55%, followed by the lack of a sense of community (33%) and by difficulties in communication (25%). What is interesting is that 8.5% mentioned that they have never done group work before.

What is most interesting about the problems encountered during team work is how they are related to the five factors that were extracted from the factor analysis (see figure 2).

Problems while doing team work:		%	Factor 1: Satisfaction with the trainers and the lessons	Factor 2: Anxiety, insecurity, boredom	Factor 3: Gain of skills and knowledge	Factor 4: Poor facilities and organisation	Factor 5: Generic disappointment
Difficulty in understanding goals/objectives	No	84.3	0.09	-0.02	0.03	-0.06	-0.09
	Yes	15.7	**-0.49**	0.12	-0.15	**0.31**	**0.47**
Difficulty in communication	No	75.2	0.06	-0.05	0.00	-0.07	-0.10
	Yes	24.8	**-0.19**	0.16	-0.01	**0.20**	**0.30**
Lack of accountability	No	90.8	0.04	0.00	0.01	-0.03	-0.09
	Yes	9.2	**-0.37**	0.03	-0.13	**0.32**	**0.90**
Lack of adequate subjective knowledge	No	88.9	0.03	0.00	0.02	-0.03	-0.12
	Yes	11.1	**-0.22**	-0.01	-0.18	**0.20**	**0.92**
Lack of support	No	88.9	0.09	-0.06	0.04	-0.10	-0.06
	Yes	11.1	**-0.68**	**0.48**	**-0.31**	**0.83**	**0.47**
Lack of leadership	No	97.4	0.01	0.00	0.00	-0.01	0.00
	Yes	2.6	**-0.47**	0.07	**0.29**	**0.46**	0.18
Lack of sense of community	No	66.7	0.08	-0.03	0.04	-0.09	-0.18
	Yes	33.3	-0.15	0.07	-0.07	0.17	**0.35**
Lack of time	No	45.1	0.09	-0.02	0.15	-0.06	-0.18
	Yes	54.9	-0.08	0.02	-0.12	0.05	0.15
Technical problems	No	88.2	0.01	-0.04	0.01	-0.05	-0.02
	Yes	11.8	-0.09	**0.33**	-0.06	**0.37**	0.15
Others (I have never done group work)	No	91.5	-0.03	0.00	0.00	0.00	0.05
	Yes	8.5	**0.29**	-0.03	0.09	0.05	**-0.51**

Fig2: Problems during group work and factor means.

Three out of four factors that are related to emotions are significantly related to many of the problems encountered during group work. A positive answer in one of the problems is less likely if the responder is satisfied with the trainers and the lessons and more likely if he or she expresses a feeling of generic disappointment or feels that the facilities and organization of the HOU are poor. The feelings of anxiety, insecurity and boredom are related to only two of the problems mentioned. What is interesting is that those who mention that have never done group work are satisfied with the trainers and the lessons, and are less likely to express a feeling of generic disappointment. The reason for that may be because the responders view it more as a personal challenge than as a real problem.

The most interesting finding showed in figure 2 is that the learning outcomes have almost no relation to the problems experienced during team work. We find factor means of some importance only for two of the problems, but these means are not very high and one of them has the opposite direction of what was expected (the lack of leadership is positively related with the skills gained). Therefore, if we assume that the experience of problems during team work indicates a poor social environment, it seems that this environment has no impact on the learning outcomes.

Finally, according to the data there is definitely a strong relation between positive emotions and the development of a social climate and vice versa, the learning outcomes are related to none of them.

CONCLUSION

This research has sought to answer whether there is the relationship among the learning outcomes, the emotional experiences of students and the social climate that develops in the distance education environment of the HOU. The data gathered from the questionnaire revealed that although there is a relationship between emotions and social interaction, none of the two variables influence the skills and knowledge acquired from the students.

There are some possible explanations for the outcomes of this research. Tzoutza's (2009) research at the HOU revealed that emotional support and encouragement from the teacher is not of primary importance for the students. Students at the HOU are more interested in academic support in order to fulfill their obligations on time. It seems that the students at the HOU control their emotional reactions and are committed to their goals, which according to Järvenoja and Järvelä (2005) is called volition.

Moreover, research by Wosnitza and Volet (2005) reported that exploring emotions in online education is difficult since students hide their feelings. Participants' unwillingness to disclose their feelings is a serious limitation when investigating emotions. There is a possibility that the participants of this study hid their true feelings about distance education and the mid-point at the Likert scale made it easier for them. Furthermore, research on emotional aspects in the Greek educational context has been neglected and respondents were unfamiliar with questions evaluating their emotional state.

The results of the research also indicated that the HOU does not promote opportunities for social interactions and group work something that Papavasiliou-Alexiou and Dimitropoulos (2009) also confirm. Additionally, most of the participants were over 30 with family, work and social obligations. It is possible that due to the limited time they have at their disposal for their studies they have poor social interactions with the other students.

The results revealed that there are significant differences relative to the gender and the age of the participants. Women experience emotions of anxiety, insecurity and boredom at higher levels than men. Finally, the participants aged from 23 to 27 were more disappointed with the trainers, the facilities and the knowledge and skills they gained that those aged from 33+.

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DO SCIENCE RESEARCH APPRENTICESHIPS ENHANCE PUPILS' INTEREST IN SCIENCE?

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Abstract: Science reforms call on schools to engage students in doing science rather than simply studying it. Research funding associations ask scientists to include activities into their research projects to demonstrate broader impacts. Student-Scientists Partnerships (SSP) are becoming more and more popular. However we only know little about what benefits both partners derive from these interactions. Science learning theory tells us that how children learn is partly determined by what they already know including the schemes and perspectives they bring to a new situation. In SSPs pupils are asked to participate in a knowledge context far beyond what they have experienced so far.
This paper is reporting on a broader impact project with high school students in the research field of ecology and climate change. While several studies on SSP programs demonstrate rather positive results our study shows that student´s content knowledge development is limited. Understanding the bigger picture was a serious challenge. Only little positive effect is observed on student's interest in science in general and on scientific topics in particular. Based on the theory of the "Four Phase Model of Interest Development" we suggest that in SSP´s students may experience feelings of autonomy and competence to a lesser extent than proposed. We finally conclude that further attempts have to be made to determine the reported empirical established set of benefits generated by SSP programs.

Keywords: student-scientist partnership; secondary education; interest in science; inquiry; ecology

BACKGROUND

More and more research funding associations ask scientists to include activities into their research projects to demonstrate broader impacts on science and society (Lok, 2010). Student-scientist partnerships (SSP) are becoming more and more popular. This study will report on a SSP´s project established through an ambitious program named "Sparkling Science". The program was launched by the Austrian Federal Ministry of Science and Research in 2008. Starting point was an increasing recruitment problem in some areas of science and technical sciences as well as high university dropout rates. Inviting pupils and their teachers to participate in authentic research projects is expected to enhance pupil's interest in science and scientific careers. This may help them to make a better choice for their university studies. Sparkling Science research projects are therefore not only focussing on publishable scientific outcomes but pupils should be included in reasonable research tasks. Students not only collect data but contribute to final publications to support learning gains on higher order outcomes (Ryder & Leach. 1999). This paper refers to a Sparkling Science project named "*Top-Klima-Science - Hydrologic balance and global change: future outlook for mountain areas in the face of changes in land use and climate*". The research focus of this project was to understand the impact of land use and climate change on the hydrologic balance in mountain areas as precisely as possible. Scientist at the Institute of Ecology at the University of Innsbruck, the European Academy Bolzano, Italy and teachers and their pupils aged 15 to 20 years from the higher agriculture school HLFS Kematen in Tyrol were partners in this two years lasting scientific endeavour.

THEORETICAL FRAMEWORK

Krapp (2005) argued that a person is always in interaction with an object or topic and this needs to be considered when analyzing human activities or development. This interaction is characterized by content, activity and context. The Person object theory of interest suggests to consider a cognitive and emotional regulation system that is responsible for both the formation of interest-related intentions and the evaluative feedback during concrete person object interactions. A basic needs system has to be understood as working holistically. The three essential “basic needs” are: social relatedness which is described as feeling of being connected and accepted by significant others, autonomy which is specified as feeling independent from undesired external and internal pressures and competence which leads to efficacious and attained valued outcomes. When students are asked about their feelings during a past sequence of learning activities they normally refer spontaneously to experiences that are obviously related to the system of basic needs.

In addition science learning theory tells us that the level of a person’s interest has not only a powerful influence on students learning (Renninger et al., 2002) but interest predicts college students choice of academic major (Harackiewicz et al., 2002). The Four Phase Model of Interest Development describes the development and deepening of learner’s interest as an ongoing process from triggered situational interest and its maintenance to emerging and finally well developed individual interest. In this model feeling of competence, autonomy and social relatedness as well as differentiated knowledge structures contribute to the interest development in all individuals (Hidi & Renninger 2006). In terms of a constructivist perspective we need to consider that what and how people learn is partly determined by what they already know including the schemes and perspectives they bring to a new situation. Pre-existing concepts about natural phenomenon’s either hinder or mediate students reasoning ability and are essential for understanding a particular scientific context (Strike &Posner, 1992, Duit & Treagust, 2003). However n this SSP´s pupils are asked to participate in a knowledge context far beyond what they have experienced already and the central tension, mentioned by Sadler et al., (2010) is inherent to SSP programs: “*scientists seek high quality data and teachers and students expect high quality learning experiences”*(p. 250). However research shows that science apprenticeships are successful in various ways but Sadler et al (2010) concludes “*that researchers have over-relied on the self-reports of participants as the basis for claims made in support of these programs*” (p.252).

PURPOSE

The research question addressed in this study was: Is there a proof for the notion that this particular Student Scientist Partnerships (SSP´s) actually “enhances student’s interest in science”.

CONTEXT AND METHODS

50 Students, aged 18 to 20, participated in this study (37 female and 13 male). A multi perspective approach based on achievement tests, questionnaires and interviews in a pre and post test design was applied. Closed questions were asked in questionnaires to learn more about pupils’ interest in and attitude towards science. These questions were based on

validated questions addresses in the OECD PISA 2006 study (PISA 2007) and the ROSE study (Elster 2007). Reconstruction of pre existing concepts was investigated via open questions students answered in a paper and pencil test as well as via individual interviews. Focus group interviews were conducted with 12 students (6 boy and 6 girls) to learn about their interest development in more detail. Students were selected based on their level of interest presented in the pre-test (in each case four students with a high, moderate and a low interest in science). Interviews were transcribed and analysed with “Qualitative Content Analysis” techniques and a score was calculated for interest as well as content knowledge development (Mayring 2008).

RESULTS

Questionnaire results revealed that students show a higher than average level of interest in most scientific topics when they entered the project. This interest more or less does not change until the end of the project. In addition student’s attitude towards science does not increase significantly at time. However there is a tendency that the apprenticeship program helped students to clarify their view about scientific studies. Many students reported that participating in the SSP had no impact on their currently held career plans. Student´s concept development was limited although many of them did achieve a better understanding of single scientific facts. Understanding the bigger picture was a serious challenge only a view of them managed to cope with. But most students reported that it is very important for them to understand what the research project is all about. Students also expected the research project to lead to clear answers to research questions and did not consider research as a long lasting process.

Focus group interview with 12 students selected according to their pre project interest in science in general and the research topic in particular revealed a much more differentiated picture. Fig.1 shows that students (S1, S2 and S5) who demonstrate an increase in interest appreciated a high level of competence, autonomy and personal relevance. Those students (S3, S4 and S12) who revealed a decrease of interest indicated that the project had no personal relevance to them. Although S3 and S4 scored high in interest at the beginning their interest obviously dropped until the end of the project. Nearly all students in Group B had in common that they did not appreciate a feeling of autonomy and they evaluated the research topic and science in general as not personally relevant.

Those students who displayed that basic needs like the feeling of competence, autonomy and social relatedness where not fulfilled are more likely to experience a decrease of interest in science in general as well as in the research topic in particular. On the contrary those who experience autonomy, competence and social integration are more likely to show an increase of interest through a longer lasting student scientist apprenticeship experience. Cognitive understanding of the research content seems to have an influence on the experience of autonomy and competence.

While students understanding of the context of the research project was limited cognitive understanding of given sub concepts related to the research question was moderate. However students self perception about understanding the context appeared to be better than exam results revealed.

Student	Appreciation of competence	Appreciation of autonomy	Social embedding	Personal relevance , fruitfulness	Cognitive understanding (Context of the research)	Cognitive understanding of details	Increase of conceptual understanding	NOS
Group A: Increase of interest (≥ +5 Score-points)								
S1	H	H	H	H	M	H	L	H
S2	H	H	M	H	M	H	M	M
S5	H	H	H	H	L	M	M	M
Group B: Interest remained constant (≤ -5 to ≤ + 4 Score-points)								
S6	M	L	M	L	L	M	M	M
S7	M	L	M	M	L	M	H	L
S8	M	L	M	N	L	M	H	L
S9	M	L	H	M	L	M	M	L
S10	N	L	M	L	L	L	L	L
S11	M	M	M	M	L	H	H	L
Group C: Decrease of Interest (≥ - 6 Score points)								
S3	L	L	M	L	L	H	H	M
S4	H	M	M	L	M	H	H	H
S12	L	L	M	L	L	L	L	L

Fig.1. Table of Students development: qualitative content analysis of focus group interviews based on a coding scheme (Mayring 2008) was developed to analyse changes in student's interest. Student S1-4 entered the project showing a high interest in science in general and in the research topic in particular. Students 5-8 showed a medium level of interest and students 9-12 a low level of interest at the beginning of the project. H = high, M = medium, L= Low range of score points.

DISSCUSSION

While several studies on SSP programs report a positive increase in content knowledge (Brown & Melear 2007, Hunter et al 2007) our study only revealed a limited growth of conceptual development, far more limited than teachers and scientists had expected. This might be caused by the fact that students did not have the complex theoretical background needed to understand research work. Although researchers spent a reasonable amount of time on explaining their research topic in great detail not enough time was given to students to become consciously aware of their own conceptions, share personal concepts within the learning community or test and compare personal conceptions with scientific models and explanations for plausibility (Ebenezer et al 2009). As far as interest development is concerned empirical results clearly show that interest-based learning is related to self-regulated learning. The quality of the learning outcomes, a differentiated knowledge and basic needs like the feeling of competence, autonomy and relatedness play a crucial role. Students who did not understand the scientific context may not experience competence and autonomy in a SSP programs and therefore may not show an increase in their interest in science in general or in scientific careers in particular. Various studies show that SSPs promote career aspirations in the sciences (Russel et al 2007, Lopatto 2004) but these results may be based on the fact that many studies focus on SSP programs students choose voluntarily whereas students in this study the students had not been asked whether they want to participate but their whole class was enrolled by an interested teacher. Only a view of the students reported to be interest in a scientific career at the beginning of the program which did not change in the course of time. Many students felt disappointed about the fact that their research did not yield a practical result. They expected clear answers to asked questions and wanted to draw consistent consequences out of their results. This judging shows us that even after spending quite some time in a research environment, pupils did not acquire an understanding of the classical meaning of science.

IMPLICATIONS

This study shows that student's interest development is influence by many aspects that need to be considered when asking young people to enter a student scientist's partnership. To assume that the mere invitation of pupils and their teachers to participate in authentic research will automatically enhance pupil's interest in science and scientific careers and may help them to make a better choice for their university carrier lacks evidence. We conclude that attempts to determine an empirical established set of benefits generated by SSP programs are still in critical needs of profound analyses. Further studies are necessary to clarify the fact whether the student interest is increase by SSPs or not.

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AN EXAMINATION OF GENDER DIFFERENCE IN MIDDLE SCHOOL STUDENTS'SCIENCE SELF-EFFICACY AND ITS SOURCES

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Abstract: This study aimed at examining the differences between boys and girls in terms of science self-efficacy and its sources. 1915 elementary students (905 females, 1010 males) participated in the study. The results indicated that there is not a statistically significant difference between boys and girls in terms of their science self-efficacy levels. Concerning sources of science self-efficacy, mastery experience was found to be the leading source for both boys and girls. Additionally, verbal persuasion and emotional arousal were found as significant predictors of students' science self-efficacy for both genders. On the other hand, vicarious experience did not significantly predict students' self-efficacy. Findings, in general, supported Bandura's theoretical contention regarding sources of self-efficacy.

Keywords: self-efficacy, sources, gender, mastery experience, vicarious experience

BACKGROUND

Self-efficacy was firstly introduced by Albert Bandura and defined as "beliefs in one's capabilities to organize and execute courses of action required to produce given attainments" (Bandura, 1997, p.3). Human functioning is greatly influenced by self-efficacy beliefs. Choices of activities people make, courses of actions they follow, effort expenditure and persistence are the most prominent ones (Pintrich & Schunk, 2002; Pajares, 2002). People generally select and engage in an activity that they believe it would yield desired results.

FRAMEWORK

According to Bandura self-efficacy is constructed by four principal sources which are mastery experiences, vicarious experiences, verbal persuasions and emotional arousal. Mastery experience is seen as the prominent source of efficacy beliefs (Bandura, 1986, 1997; Hoy, 2004). This is because experience is personal, or in other words authentic, which presents all endeavors to attain success. People do not judge their level of capabilities just by interpreting personal performance accomplishments. The observed actions of others or the observed performance on a task help individuals to form their efficacy beliefs. The calibration of capabilities in comparison with others is known as the vicarious experience (Usher & Pajares, 2008). The third hypothesized source of self-efficacy is verbal or social persuasions. Verbal persuasions and social support encourage individuals to persist on the task at hand and resist to aversive situations (Zeldin & Pajares, 2000). The fourth and last hypothesized source of efficacy beliefs is physiological states or emotional arousal. Stress, fatigue, mood, tension, emotion, and pain can be addressed as physiological states. They all may be influential when making judgments on self-efficacy (Hodges & Murphy, 2009). However, studies focusing on sources of self-efficacy beliefs in terms of gender differences suggested that relative contribution of the sources to the formation of students' self-efficacy may differ depending on gender. For example, working with 263 elementary school students, Usher and Pajares (2006) found that for the full sample, mastery experiences, social persuasions and physiological states were significant predictors of students' self-efficacy beliefs. Mastery experience was found to be the strongest source contributing to self-efficacy. For girls, on the other hand, social persuasions were the strongest source while mastery experience made the second strongest contribution to the self-efficacy beliefs. In contrast, for boys, vicarious and mastery experiences significantly predicted academic self-efficacy. In another study, Britner and Pajares (2006) examined sources of science self-efficacy beliefs of 319 elementary school students. The study indicated that there is not a significant mean difference between boys and girls in terms of science self-efficacy beliefs. Of the four sources, only mastery experience significantly predicted science self-efficacy for the full sample, for boys and for girls. Also mastery experience made the largest contribution of unique variance in each case (24 % for the full sample, 17 % for boys and 35 % for girls). The remaining sources have made only minor contributions to the prediction of science self-efficacy. Thus, although the research investigating sources of self-efficacy beliefs generally demonstrated that mastery experience is the leading source of students' self-efficacy beliefs, the relative contribution of each source may show differences as a function of gender.

PURPOSE

Considering the relevant literature, this study focuses on the differences between boys and girls in terms of science self-efficacy and its sources. Accordingly, the present study aims at addressing the following research question:

1. Is there a difference between boys and girls with respect to level of science self-efficacy beliefs towards science?

2. How well mastery experiences, vicarious experiences, verbal persuasions and emotional arousal predict girls' science self-efficacy beliefs?

3. How well mastery experiences, vicarious experiences, verbal persuasions and emotional arousal predict girls' science self-efficacy beliefs?

RATIONALE

Although the level of self-efficacy towards various domains (especially mathematics) was studied, science self-efficacy is studied rarely. Moreover, examination of sources of science self-efficacy is a big gap in the literature. Researchers generally studied the sources of math self-efficacy and sources of math-science career self-efficacy.

METHODS

1915 elementary 8th grade students (905 females, 1010 males) constituted the sample of the study. The Sources of Science Self-Efficacy Scale, which is a five point Likert scale and developed by Lent, Lopez and Bieschke (1991), was used to assess eight grade students' sources of science self-efficacy beliefs. For assessing level of science self-efficacy, self-efficacy sub dimension of MSLQ was used. MSLQ is a 7 point likert type scale and developed by Pintrich, Smith, Garcia, and McKeachie (1993).

RESULTS

For the first research question, to identify whether there is a significant mean difference between boys and girls in terms of level of science self-efficacy, one way ANOVA was conducted. The results indicated that there is not a significant mean difference between boys and girls at the .05 significance level (F (1, 1913) = .305, p = .58). For the second and third research questions, Multiple Linear Regression Analyses were conducted. As shown in Table 1, all sources except vicarious experience significantly predicted science self-efficacy for both genders. Of the sources, mastery experience made the largest contribution to the explained variance for both genders (sr^2 = 8 %). For girls, verbal persuasions made a relatively small contribution to the variance (sr^2 = 2 %) and emotional arousal made a minor contribution (sr^2 = 1 %). For boys, emotional arousal and verbal persuasions made nearly equal contribution to the explained variance (sr^2 = ~2 %).

TABLE 1
Regression analysis results of sources of science self-efficacy for genders

	Girls				Boys			
	Standardized Coefficients	Sig.	Correlations	sr^2	Standardized Coefficients	Sig.	Correlations	sr^2
	Beta		Part (sr)		Beta		Part (sr)	
Emotional Arousal	.17	**.004***	.07	.01	.18	**.000***	.14	.02
Mastery Experience	.80	**.000***	.28	.08	.40	**.000***	.28	.08
Verbal Persuasions	.38	**.000***	.14	.02	.20	**.000***	.15	.02
Vicarious Experience	.01	.209	.03	.00	.02	.571	.01	.00
R	.70				.69			
R^2	.49				.48			

CONCLUSIONS AND IMPLICATIONS

In line with the findings, it is concluded that there is not a statistically significant difference in terms of level of science self-efficacy between boys and girls. This finding was consistent with previous research which revealed no gender difference not only in science but also in general academic self-efficacy and in math self-efficacy (Lopez & Lent, 1992; Lent et al, 1991; Hampton & Mason, 2003). Concerning sources of science self-efficacy, mastery experience was found to be the leading source for both boys and girls. It is consistent with Bandura's theoretical consideration regarding mastery experiences. Empirical studies also support this finding (e.g. Britner & Pajares, 2006; Lopez, Lent, Brown, & Gore, 1997).

The present study also revealed verbal persuasions as significant predictor of students' science self-efficacy for both genders. For science domain, Britner & Pajares (2006) could not find verbal persuasions as a source. However, in their study, verbal persuasions were correlated with self-efficacy. Therefore, they suggest considering verbal persuasions as an antecedent of self-efficacy. They assert that social persuasions influence students' mastery experience in a positive manner. Encouragements provided by significant others bolster students' self-efficacy. However, it should be kept in mind that negative social persuasions are easily decreasing students' self-efficacy rather than increasing it with positive messages.

Concerning emotional arousal, it explained more variance in boys' science self-efficacy than that of girls. Although Britner & Pajares (2006) could not find emotional arousal as a source for science self-efficacy for both genders, Usher & Pajares (2006) found that emotional arousal is a significant source for boys' self-efficacy. In another study by Gainor & Lent (1997), emotional arousal was found as a significant source in math self-efficacy for both genders. Thus, there is a variety in findings regarding contribution of emotional arousal to students' self-efficacy.

On the other hand, in the current study, vicarious experience was not found as a significant source of self-efficacy for both genders. For science domain, it is consistent with the literature (Britner & Pajares, 2006) but, in other domains like career, math and academic self-efficacy, vicarious experiences make significant contributions to the explained variance (Lopez, Lent, Brown & Gore, 1997; Zeldin, Britner & Pajares, 2008; Usher, 2009). Although Bandura's (1997) contention regarding vicarious experiences in terms of group work and collaborative activities, in Turkish context it did not emerge as a significant source of science self-efficacy. This may be due to the competitive and normative examination system of Turkish education system. Students might have relied on their mastery experiences (performance accomplishment) in forming their self-efficacy rather than modeling their peers.

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THE EFFECT OF METACONCEPTUAL TEACHING INTERVENTIONS ON STUDENTS' SELF-EFFICACY TOWARD CHEMISTRY

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Abstract: The purpose of this study was to examine the effectiveness of metaconceptual teaching interventions (MTI) on 10th grade students' self-efficacy toward chemistry compared to traditional instruction (TI). This study employed the matching-only pretest-posttest control group design as a type of quasi-experimental design. The sample of this study consisted of 102 10th grade students with two experimental and control groups. There were 53 students in the experimental groups and 49 students in the control groups. Students in experimental groups were instructed by MTI and students in the control groups were instructed by TI. To examine the effect of MTI on students' self-efficacy toward chemistry, high school chemistry self-efficacy scale (HCSS) was administered to the students in the experimental and control groups two weeks before the treatment and at the end of the treatment. HCSS consisted of 16 items with a 9-point scale ranging from very poorly to very well in two dimensions: chemistry self-efficacy for cognitive skills (CSCS) and self-efficacy for chemistry laboratory (SCL). Multivariate analysis of covariance was used to determine the effectiveness of two different instructional methods on students' self-efficacy. The results of the analysis revealed that there was a significant mean difference on the collective dependent variables of post-CSCS and post-SCL between experimental and control groups when the covariates were controlled.

Keywords: metacognition, states of matter, self-efficacy, MANCOVA, science education

INTRODUCTION

In the literature, there has been an increased attention on metacognition among researchers. The term "metacognition" was first introduced by Flavell in the early 1970s. Flavell (1979) defined metacognition as "knowledge and cognition about cognitive phenomena" (p. 906). Metacognition is a fuzzy concept and it lacks coherence in terms of its meaning and components (Brown, 1987). For example, Baird (1990) defined metacognition as "knowledge, awareness and control of one's own learning" (p. 184). Rickey and Stacy (2000) interpreted metacognition as "thinking about one's own thinking" (p. 915). Several researchers have proposed different models regarding components of metacognition. According to Flavell (1979), metacognition consisted of the components of "metacognitive knowledge" and "metacognitive experience". Chi (1987) identified three types of metaknowledge: meta-declarative knowledge, meta-procedural knowledge, and meta-strategies. Metacognition is widely believed to make students responsible for their learning and thus students more actively involved in the learning process (e.g., Hennessey, 1999). The continuing research into metacognition has provided that metacognitive teaching activities had positive impact on student thinking skills and conceptual understanding (e.g., Hennessey, 1999; Hewson, Beeth, & Thorley, 1998). There is also growing literature investigating the relationship between self-regulation (including metacognition) and motivational beliefs (e.g., Sungur, 2007). However, the literature lacks the studies examining the effect of metacognitive teaching activities on students' motivational beliefs. Self-efficacy is one of the important components of motivation.

Self-efficacy plays a crucial role in science education. According to social cognitive theory, Bandura (1997) defined self-efficacy as “beliefs in one’s capabilities to organize and execute courses of action required to produce given attainments” (p. 3). Self-efficacy beliefs are effective on students’ actions regarding how much effort they expend on an activity and how long they put perseverance into an action when they face with difficulties. High efficacious students set challenging goals, put greater efforts on an activity, and persevere when dealing with difficulties. However, low efficacious students may not show perseverance and resilience when confronting setbacks (Pajares, 1996). In the literature, it has been reported that there was an increase in the number of students who lacked confidence and interest in science (Pell & Jarvis, 2001). Therefore, it is important to find ways to increase students’ self-efficacy. There is no study in the literature investigating the effect of metaconceptual teaching activities on students’ self-efficacy toward chemistry as a school subject. The purpose of this study was to examine the effectiveness of metaconceptual teaching interventions (MTI) on 10th grade students’ self-efficacy toward chemistry as a school subject compared to traditional instruction (TI). This study focuses on the following research question:

- What is the effect of MTI on 10th grade students’ self-efficacy toward chemistry when the effect of self-efficacy toward chemistry pretest scores is accounted for?

METHODS

Sample and population

The target population of this study was all 10th grade high school students in a city in Turkey. There are seven high schools in the city and all 10th grade students at seven of the two high schools were determined as the accessible population of the study. The sample of this study consisted of 102 students from two classes of each high school, which matched more than ten percent of the whole population. The sample of the study was chosen from the accessible population by using convenience sampling. There are three 10th grade science classes in each high school and two of the classes which were taught by the same chemistry teacher was randomly assigned to the experimental and control groups. Students’ socio-economic status was middle. The ages of the students are ranged from 15 to 16. Students in experimental groups were instructed by MTI and students in control groups were instructed by TI. There were 53 students (66% females and 34% males) in the experimental groups and 49 students (53% females and 47% males) in the control groups.

Instrument

To examine the effect of MTI on students’ self-efficacy toward chemistry, High School Chemistry Self-Efficacy Scale (HCSS) developed by Capa Aydin and Uzuntiryaki (2009) was administered to students. HCSS consisted of 16 items with a 9-point scale ranging from very poorly to very well in two dimensions: chemistry self-efficacy for cognitive skills (CSCS) and self-efficacy for chemistry laboratory (SCL). The CSCS was described as “students’ beliefs in their ability to use intellectual skills in chemistry” and the SCL was defined as “students’ beliefs in their ability to accomplish laboratory tasks including skills in both cognitive and psychomotor domain” (Capa Aydin & Uzuntiryaki, 2009, p. 872). The CSCS consisted of 10 items and the SCL consisted of 6 items. In a 9-point scale, very poorly was graded as 1 point and very well was graded as 9 point. Students needed up 10 to 15 minutes to complete the HCSS. The HCSS was piloted by the researcher with a sample of 330 high school students. It was found that HCSS consisted of the same two-factor structure as Capa Aydin and Uzuntiryaki (2009) proposed: CSCS (10 items) and SCL (six items). The internal consistencies of scores on the two dimensions were estimated by Cronbach alpha coefficient.

In the pilot study, Cronbach alpha reliability coefficients for the CSCS and SCL scores were found to be .86 and .93, respectively.

Procedure

In this study, the matching-only pretest-posttest control group design as a type of quasi-experimental design was used. Two months before the implementation started, the researcher was present at the research setting in order to have students get used to video recordings. During two months, the researcher recorded videos of the lessons of four classes included in the main study. The researcher also made observations during lessons in order to help her in selecting case studies for the main study in future. Furthermore, the researcher piloted metaconceptual activities prepared in chemical bonding topic during this time. The teachers in this study were trained for MTI during two months before the implementation began. To examine the effect of MTI on students' self-efficacy toward chemistry, HCSS was administered to the students in experimental and control groups two weeks before the treatment and at the end of the treatment. Before the study commenced, the researcher trained the teachers regarding MTI. Students in the experimental and control groups were taught by MTI and TI, respectively. There was a seven-week treatment period covering the science subject of "states of matter" with four-hour chemistry course a week. In the experimental group, several metaconceptual teaching activities such as poster drawing, journal writing, group discussion, and class discussion were included in order to facilitate students' metaconceptual processes. Metaconceptual teaching activities were arranged to make students aware of their own ideas, to monitor their understanding of a new concept, and to evaluate their ideas. The same set of activities such as experiments and class discussions was also used in the control group without explicit attempt to facilitate students' metaconceptual knowledge and processes. Table 1.1 shows a sample poster drawing activity used in the experimental group.

Table 1

A Sample Poster Drawing Activity

Aktivity: Poster Drawing

Types of metaconceptual processes that can be activated through poster drawing: Students' metaconceptual awareness, metaconceptual monitoring, and metaconceptual evaluation of their own ideas and ideas from other people/sources are tried to be activated.

Topic:

1. States of matter
2. Gas pressure
3. Pressure-temperature relationship in gases
4. Pressure-volume relationship in gases

Presentation of the topic:

1. Students will form five working groups of five students and the following questions were given as worksheets to the groups. Every student in the group will discuss her/his ideas on the answers of each question. Group discussions will be recorded on audiotapes.
   - How would you describe the difference among solids, liquids and gases?

Table 1 (*continued*)

- Suppose you had water in solid, liquid, and gas states. What do you think about the mass and density of water in each state?
- How can you draw the picture of solids, liquids and gases (for example, suppose you had water in solid, liquid, and gas states) in terms of the particulates that make up each?
- How can you explain gas pressure?
- What do you think how the gas pressure changes as altitude increases? Why?
- How can you explain pressure-temperature relationship in gases by giving daily life examples?
- How can you explain pressure-volume relationship in gases by giving daily life examples?

The groups will be given A3 papers and colorful pencils to draw their ideas on it. Every group will present their posters to the classroom.

Data analysis

Multivariate analysis of covariance (MANCOVA) was used to determine the effectiveness of two different instructional methods on students' self-efficacy toward chemistry by controlling the effect of students' CSCS and SCL pretest scores as covariates. MANCOVA has five assumptions: normality, homogeneity of regression, homogeneity of variance-covariance matrices, multicollinearity, and independency of observations. All these assumptions were checked and were satisfied.

RESULTS

The MANCOVA was conducted. Dependent variables of this study were post-CSCS and post-SCL scores and the fixed factor of this study was method of teaching. CSCS and SCL pretest scores were used as covariates. Before the study started, the necessary sample size for the desired power of the study was calculated. Cohen, Cohen, West and Aiken (2003) proposed effect size values for f^2 as "small" = .02, "medium" = .15, and "large" = .35. In this study, the effect size was set to a medium effect size measured by f^2 as .15 since there are not many studies to consider while deciding on the effect size. The significance level was set to .05 as in most of the educational studies. The power of the study was set to .80. The necessary sample size was calculated as 55. The results of the analysis revealed that there was a significant mean difference on the collective dependent variables of post-CSCS and post-SCL between experimental and control groups when the covariates were controlled (Wilks' λ = .93; $F(2,97) = 3.40$; $p = .04$). The partial eta square value was found to be .07 which indicated a medium effect size according to Cohen's (as cited in Pallant, 2001) suggestions (.01 = small effect, .06 = medium effect, and .14 = large effect). The power was obtained as .63 which was lower than the pre-calculated power value. In order to test the effect of the treatment on each dependent variable, an analysis of covariance (ANCOVA) was performed as follow-up tests to the MANCOVA. It was found that method of teaching had a significant effect on the dependent variable of post-SCL ($F(1,98) = 6.70$, $p = .01$) with medium effect size. Partial eta square was calculated as .07. The power of the study was found to be .73. However, method of teaching did not have a significant effect on the dependent variable of post-CSCS ($F(1,98) = 0.88$, $p = .35$).

CONCLUSIONS AND IMPLICATIONS

In the literature, there are studies modeling the relationship between motivational beliefs (including self-efficacy beliefs) and metacognitive strategy use (e.g., Sungur, 2007); however, there is no study investigating the effect of MTI on students' self-efficacy beliefs. For example, Sungur (2007) proposed a path model to examine the relationships among motivational beliefs, effort regulation in science courses, and metacognitive strategy use. She found that motivational beliefs and performance were predictors of students' metacognitive strategy use. The current study concluded that MTI increased students' scores on the collective dependent variables of post-CSCS and post-SCL and students' scores on the individual dependent variable of post-SCL compared to TI. Researchers have documented that modeling (Pajares, 1996) and feedback (Butler & Winne, 1995) increased students' self-efficacy. During the MTI treatment, students participated in the metaconceptual teaching activities such as poster drawing, group discussion, and class discussion and students' metaconceptual awareness, monitoring, and evaluation of their ideas were tried to be activated. Therefore, it could be said that throughout the MTI treatment, students found opportunities to get feedback on their ideas and to model their peers and teachers. Curriculum developers and teachers should be aware of the effect of MTI on students' self-efficacy and design the curriculum and courses accordingly. The further research could be conducted with large sample size to examine the effect of MTI on students' self-efficacy. Also, interviews could be conducted to get more detailed view for the effect of MTI on students' self-efficacy.

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Differences in Students' Situational Interest and Learning Achievement Caused by Learning with Different Contexts

Eva Kölbach & Elke Sumfleth

Abstract: Although, context-orientation is implemented in the German school curricular of North Rhine-Westphalia (federal state of Germany), there is still a lack of research-based evaluation into the effects of their use. While most evaluation studies show that context-orientation has a positive influence on students' interest and motivation, context-effects on students' learning achievement are less positive and inconsistent (Bennett & Holman, 2002). Fechner (2009) showed for the chemistry domain that students learning with real-life contexts outperform students learning with subject-related contexts in a situational interest questionnaire as well as in accompanying achievement tests. However, effects vary depending on the implemented context.

The present study investigates context-effects on students' situational interest and learning achievement while learning different chemistry contents. Context-based worked-out examples served as learning material. Effects of the study were measured in a pre-post-follow-up design by the use of paper-pencil tests. Results show a main effect of context-oriented learning on students' situational interest with effects varying depending on the respective chemical content-knowledge.

Keywords: Context, Concept, Interest, Learning Achievement

1. INTRODUCTION

As a consequence of the weak performance of students in large scale assessments like *PISA* and *TIMSS*, the German government rethought about the German educational system. This move was underpinned by the implementation of federal state curricular determining that science concepts are better to be learned by students, when they are connected to real life problems. Therefore, in the new curricular of North Rhine-Westphalia every chemical concept is related to a (real-life) context, in which the concept has to be learned by the students. In this way context-orientation is used for pre structuring curricular content to help students to build a more in-depth understanding of scientific concepts. Furthermore, real-life contexts are supposed to increase students' interest in learning science as well as to show the relevance of science to them. In sum, the implementation of real-life contexts (in German science curricular) should (1) increase students' interest, (2) show the relevance of science to them and (3) enhance students learning achievement.

Research on context-oriented learning has shown positive effects of context-orientation on students' interest and motivation (Barber, 2000; Osborne & Collins, 2001; Ramsden, 1997; Yager & Weld, 1999). In comparison research on context-effects on students' learning achievement are inconsistent and less positive, so far (e. g. Barker & Millar, 2001; Gutwill-Wise, 2001).

Concerning the integration of situational interest and learning achievement Fechner (2009) showed for the chemistry domain that real-life contexts encourage students' interest in general. Thereby, an increase of interest, in turn, mediates an improved learning outcome. However, both effects varied depending on the implemented context.

In sum, research on context-oriented learning used a wide range of different context-based materials. Thus, drawing generalized predictions on the effects of context-oriented learning is difficult. Accordingly, Bennett and Holman (2002) showed that there is a comparative lack of systematic-based research into the effects of their use.
The present study contributes to a more detailed evaluation of context-effects of students' situational interest and achievement concerning two different chemistry concepts. Therefore, the following research question will be investigated: What influences do a real-life and a subject-specific context have on the learning outcome across two concepts within chemistry education? Therefore, it is suggested that students learning with real-life contexts outperform students learning with subject-related contexts regarding their situational interest as well as their acquired knowledge.

2. METHODS

To investigate the research question two contexts were chosen. The real-life one is *lakes* and the subject-related one is *school laboratory*. The first one is connected to students out of school experiences the latter one is close to students' everyday life experiences in classroom. In order to their prior knowledge students were assigned to one of these two context-groups. Each of the two context-groups was confronted with two topics taken from the chemistry curriculum, namely '*structure and solution of salt*' and '*structure of water-molecules*'. Each group were asked to learn with worked-out examples (according to Mackensen-Friedrichs, 2004) embedded in the respective contexts. Overall, eight worked-out examples were developed. Every example consists of a context-based problem statement (problem formulation), several problem solving steps (solution steps with reference to the respective context) and finally the solution itself (answer). While the context group learned with examples in which the respective chemistry concepts are embedded in the cover story *lakes*, the group without context learned the same concepts following the same solution steps embedded in a *laboratory environment* (see fig. 1).

<table>
<tr><td rowspan="4">Pre test:

Interest
Self-concept
Prior knowledge</td><td colspan="3">Learning phase - learning of chemistry topics by the use of worked-out examples</td><td rowspan="4">Post-test:
(accompanying)

Situational interest
Achievement</td><td rowspan="4">Follow-up:

Achievement</td></tr>
<tr><td>content / context</td><td>structure and solution of salt</td><td>structure of the water-molecule</td></tr>
<tr><td>real-life context</td><td>2 examples</td><td>2 examples</td></tr>
<tr><td>subject-specific context</td><td>2 examples</td><td>2 examples</td></tr>
</table>

Fig 1: Overview about the used design

To measure context-effects a pre-post-follow-up design was used. First of all, the assessed control variables were collected in the pre-test. Data from the pre-test were used to ensure, that context-effects will not be returned to differences in the treatment groups.

Afterwards, a two day long learning phase took place (fig. 1). During these intervention phases each context group was provided with worked-out examples, which are employed to learn the respective concepts embedded in one context. After each learning phase, a 20-minute paper-pencil test measuring situational interest and the learning achievement were administered to the students. The achievement test includes items measuring students' subject-specific knowledge as well as items measuring their ability to transfer knowledge. Four weeks after the intervention had taken place the achievement test was administered to the students again to measure their long term knowledge.

3. Results

The study was conducted with 176 9th graders from seven different higher track secondary schools in North Rhine-Westphalia. Students were excluded from the main analysis when (1) they were spotted as outliers in the data set (z-values > 3.29) or when they were missing at least one day. Therefore, the final sample consists of 158 students. The mean age of the sample was 14.5 years (SD = 0.6) and about 53% were female. In order to their prior knowledge, students were assigned to one of the two context-treatments. To check for group differences a Chi²-test (sex / treatment) as well as a multivariate analysis of variance [MANOVA] with interest, cognitive abilities (Heller & Perleth, 2000), prior knowledge and self-concept were calculated. Neither the Chi²-test ($\chi^2(1) = .65$; $p > .05$) nor the MANOVA ($F(9,143) < 1$) revealed a significant main effect of treatment, but there were marginal effects ($p < .10$) on two scales, which were treated as covariates in the following analysis.

First, a multivariate analysis of covariance [MANCOVA] with context (subject-related / real-life) showed a main effect of context on students' situational interest ($F(2,153) = 5.95$; p = .003, partial $\eta^2 = .072$). Students learning with real-life the context (M = 3.51; SD = 0.94) showed higher situational interest than students learning with the subject-related context (M = 3.06; SD = 0.92).

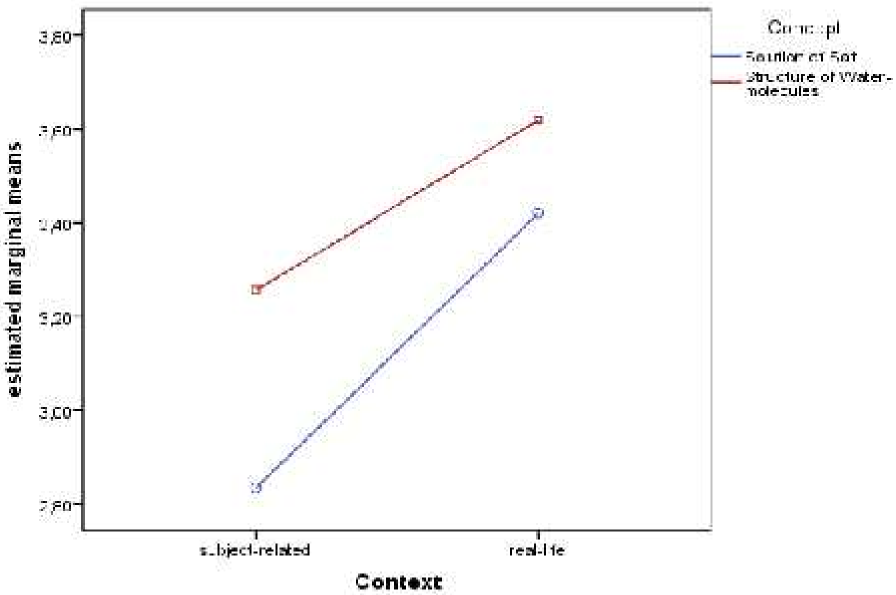

Fig2: Group differences in situational interest caused by context.

Thereby, effect-sizes varied depending on the respective content knowledge which should be acquired. Isolated analysis of covariance showed that effects were higher for the concept '*structure and solution of salt'* ($F(1,154) = 11.47$, p = .001; partial $\eta^2 = .069$) than for the concept '*structure of water-molecules*' ($F(1,154) = 5.37$, p = .022; partial $\eta^2 = .034$ (see fig 2). Therefore, it is suggested that water in this case is concept as well as context itself.

Second, data revealed an increased learning achievement from pre-test to post-test, $t(157) = 17.23$, $p < .001$, $d=1.3$. Therefore, it is suggested that the learning materials were conducive.

Third an analysis of covariance with context (subject-related / real-life) predicting students' learning achievement did not show any main effect of context ($F(2,153) = 1.64$; $p > .10$). Furthermore, data revealed no interaction effect of treatment and time of measurement (pre, post, follow-up). Also, none of the control variables served as moderator variable.

Fourth, an analysis of covariance with context (subject-related / real-life) predicting students' perceived relevance showed a main effect of context ($F(2,153) = 10.50$; $p < .001$, partial $\eta^2 = .121$). Students learning with real-life the context showed higher perceived relevance than students learning with the subject-related context. Thereby, effect-sizes varied depending on the respective content knowledge to be acquired. Isolated analysis of covariance showed that the effect was completely aroused by the concept '*structure and solution of salt'* ($F(1,154) = 19.56$, $p < .001$; partial $\eta^2 = .109$). There was no main effect of context for the concept '*structure of water-molecules*' ($F(1,154) < 1$ (see fig. 3).

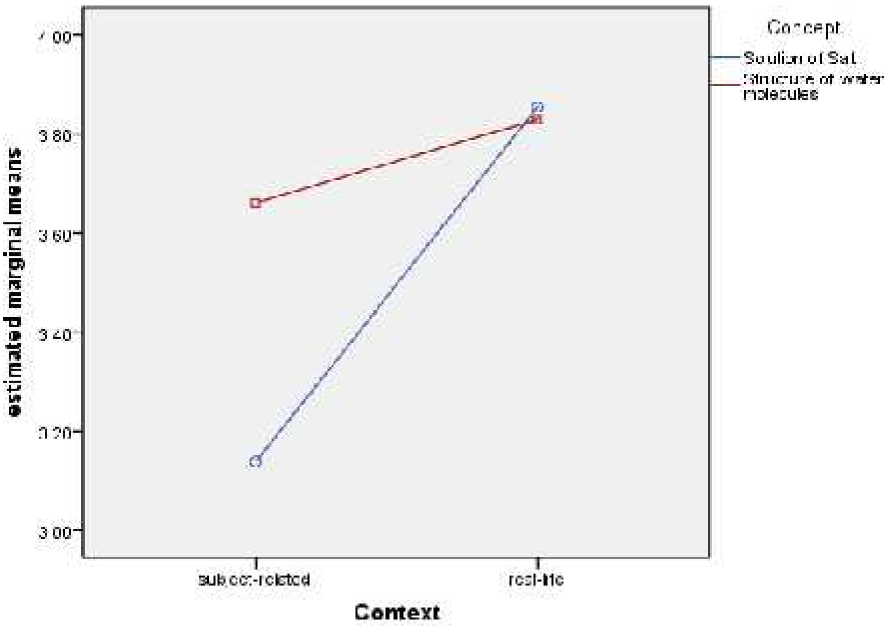

Fig. 3: Group differences in perceived relevance caused by context.

In sum, students learning with real-life contexts show – in line with our hypothesis – a higher situational interest than students learning with subject-related contexts. Contrary to our hypothesis there is no main effect of context on students' learning achievement. However, students' in the real-life context show an equal level of understanding of science concepts.

4. DISCUSSION AND CONCLUSIONS

Concerning educational implications, this research tries to provide evidence on how contexts can show the relevance of science to students' and increase students' interest in learning scientific concepts. Furthermore, it showed that the closer concepts and contexts are the smaller seamed the effect on students' situational interest and perceived relevance. In addition, it showed that in contrary to some criticism contexts don't hinder the development of scientific understanding.

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HIGH SCHOOL STUDENTS' DOMAIN SPECIFIC EPISTEMOLOGICAL BELIEFS AND THEIR CONCEPTUAL CHANGE

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Abstract: Although research on epistemological beliefs has expanded and intensified considerably over the past two decades, there are still some issues that need to be explored. The purposes of this study were to determine high school students' epistemological beliefs in the domain of physics and to examine any relationship between their beliefs and their conceptual change in physics. Case study design with qualitative methods was guided to the research. The research was conducted with 17 tenth-grade students studying in an urban high school. Physics Related Epistemological Beliefs Instrument (PEBI) was developed to determine the students' epistemological beliefs in the domain of physics. Furthermore, Assessment Instrument for the Subjects of Work, Power, and Energy (AIWPE) was developed by considering the common misconceptions discovered in the literature review to assess students' conceptual change. Data were collected in the physics class and analyzed qualitatively. The following conclusions can be drawn from the study. First, high school students' level of epistemological beliefs in the domain of physics is very close to sophistication. Second, there is a positive association between the students' physics epistemological beliefs and their learning gains. This current study would contribute to the literature toward a better understanding of the relationship between beliefs and learning by using qualitative research methods.

Keywords: Epistemological beliefs, domain specific, conceptual change, high school students, physics

BACKGROUND AND PURPOSE OF THE STUDY

Research indicates that students' epistemological beliefs may either enhance or constrain the scope and nature of the motivational beliefs, learning strategies, and knowledge that are accessible to the learner as well as the nature and quality of various learning outcomes (Paulsen & Wells, 1998). Therefore, students' epistemological beliefs have come into prominence. Although there is valuable research on epistemological beliefs, there are still some issues that need to be explored. One issue that is under discussion is how epistemological beliefs are related to learning. The purposes of this study were to determine high school students' epistemological beliefs in the domain of physics and to examine any relationship between their beliefs and their conceptual learning in physics.

THEORETICAL FRAMEWORK

Theoretical framework of this study is based on the conceptual change model (or CCM) developed by Posner, Strike, Hewson, and Gertzog (1982). According to this model, learning involves an interaction between new and existing conceptions with the outcome being dependent on the nature of the interaction. There are two major components to the CCM (Hewson, 1992). The first of these components is the conditions that need to be met (or no longer met) with the status of a person's conception in order for a person to experience conceptual change. The second component is the person's conceptual ecology (following Toulmin, 1972) described as the existing interrelated networks of concepts that influence the selection of a new concept playing a central and organizing role in thought. Several elements of conceptual ecology are identified as anomalies, analogies, metaphors, epistemological beliefs, metaphysical beliefs, knowledge from other areas of inquiry, and knowledge of competing conceptions. Therefore, personal epistemological beliefs, namely, beliefs about the nature of knowledge and acquisition of knowledge were considered as playing an important role in learning.

LITERATURE REVIEW

A few researchers have investigated student epistemologies in the domain of physics. May and Etkina (2002), for instance, illustrated that students with high conceptual gains tended to show reflection on learning that was more articulate and epistemologically sophisticated than students with lower conceptual gains. Moreover, Songer and Linn (1991), Qian and Alverman (1995), and Stathopoulou and Vosniadou (2007) put forward some evidence presenting the relationship between constructivist physics epistemology and conceptual understanding. Qian and Alvermann (1995) carried out canonical correlation analyses and expressed that beliefs about simple-certain knowledge contribute the most to conceptual change learning, whereas beliefs about innate ability contribute the least. Naive epistemological beliefs have long been identified as a major impediment to the achievement of conceptual change in science education (Thoermer & Sodian, 2002).

Moreover, (Hammer, 1994) studied college students' beliefs about the structure, content, and learning processes of physics and Roth and Roychoudhury (1994) examined the constructivist or objectivist ''epistemological commitment'' of high school physics students. Results of this study would add to the literature by exploring interrelationship between individuals' physics epistemological beliefs and their conceptual change.

METHODS

Case study design (Stake, 1995) with qualitative and quantitative methods was guided the research.

Participants and Setting

The research was conducted with 17 tenth-grade students studying in an urban high school. Their average age was 16. There were 9 females. Data were collected in their physics class.

Measurements

Two instruments were developed and used for this study. Physics Related Epistemological Beliefs Instrument (PEBI) was developed to determine the students' epistemological beliefs in the domain of physics. Schommer (1990) proposed four dimensions to measure epistemological beliefs. These dimensions are simple knowledge and certain knowledge- naive beliefs about the nature of knowledge- and innate ability and quick learning- naive beliefs about the acquisition of knowledge. Her dimensions were taken into account for this research. Thus, eight open-ended questions based on the dimensions were created for the PEBI. The questions were prepared to ask students their opinions about some scientific claims and whom they agree with in controversial dialogues between two people. Furthermore, Assessment Instrument for the Subjects of Work, Power, and Energy (AIWPE) was developed to assess students' conceptual change. The AIWPE consisted of 13 open-ended questions measuring conceptual and procedural knowledge. Each question is worth five points; thus, the highest score that someone gets from the instrument was 65. Based on Bloom's Taxonomy, one question was in knowledge level, four questions were in comprehension level, three questions were in application level and five questions were in analysis level.

Content and face validities of the instruments were ensured by working together with three experts. They were both pilot tested.

Data Collection

The PEBI was used in the semi-structured interview protocol. The interviews lasted 20 to 45 minutes and were video-recorded. Video records were examined to make sure that the interviewer did not orient students without being aware of. The students' knowledge of work, power and energy subjects was assessed in the pre-test before the instruction started. The instruction lasted six weeks. They gave their responses to the questions in the AIWPE one more time in the post-test. Each application lasted one lesson hour.

Data Analysis

Data were analyzed qualitatively. The students' epistemological beliefs were categorized as low, medium, high, and very high for each dimension because beliefs are held in clusters. The students' knowledge for each question was categorized as compatible elaborate, compatible sketchy, compatible-incompatible, incompatible sketchy, incompatible elaborate, and no response based on the bidemensional coding offered by Hogan and Fisherkeller (1996). Based on this scale, participants' response concurring with the scientific proposition and having sufficient detail to show the thinking behind them was coded as "compatible elaborate". However, if the essential details were missing, it was coded as "compatible sketchy". Participants' response disagreeing with the scientific proposition and having details or coherent logic was coded as "incompatible elaborate". Nevertheless, if very little detail or logic was given in the response, it was coded as "incompatible sketchy". If the participant made sketchy statements concurring with the scientific proposition and s/he also made sketchy statements disagreeing with the scientific proposition, his/her knowledge was coded as "compatible/incompatible". If there was no response, it was coded as "no response".

In order to determine if the change between pre- and post-tests was significant, paired samples t-test was performed.

One of the authors categorized all of the participants' beliefs. The other author also categorized some randomly selected students' beliefs. Then, two authors compared their categorization and reached 87% of agreement. They re-categorized the beliefs that they could not have agreement on and gave final decisions together. Interrater reliability value for the knowledge categorization was 91%. The authors worked on the categories where there was disagreement and reached consensus.

After coding process was completed, the researchers looked for patterns (Miles & Huberman, 1994) among the students' epistemological beliefs, conceptual change and learning strategies to find a relationship and to explain this relationship.

RESULTS AND DISCUSSION

The students' epistemological beliefs in the domain of physics are shown as percentage values in Table 1.

Regarding simplicity of knowledge dimension, more than a half of the students' (59%) were able to reach high level, 29% of the students had medium level beliefs, and 12% of them held low-level beliefs. In certainty of knowledge dimension, on the other hand, 6% of the students had very high-level beliefs, 59% of them had high-level beliefs, and 35% of them held medium-level beliefs. In innate ability dimension, 6% of the students had very-high level beliefs, 70% of them had high-level beliefs, 18% of them held medium-level beliefs, and 6% of them held low-level beliefs. In terms of quick learning dimension, while high population of the students (88%) had high-level beliefs, 6% of the students achieved to very high levels, and only 6% of them held medium-level beliefs. Findings show that majority of the students' epistemological belief level in the domain of physics was high. This result is compatible with Yang's (2005) finding that most students were multiplist. On the other hand, the result of the current study is not in line with May and Etkina (2002)'s result. They demonstrated that many high school students considered science as a collection of facts and did not differentiate between observational evidence and explanations of this evidence. Findings of the current study also reveal that the dimension that nearly all of the students developed nearly sophisticated physics epistemological beliefs in was quick learning dimension. That is, the students believed that learning was a gradual enterprise and did not occur quickly. However, it was hard for almost a half of the students to believe that knowledge was composed of highly interrelated concepts.

Table 1. *Percentage values of the students' epistemological beliefs in the domain of physics (N=17)*

Dimensions	**Epistemological Beliefs in the Domain of Physics (%)**			
	Low	**Medium**	**High**	**Very High**
Simplicity of Knowledge	12	29	59	0
Certainty of Knowledge	0	35	59	6
Innate Ability	6	18	70	6
Quick Learning	0	6	88	6

The results of paired samples t-tests illustrated that the students showed significantly higher performance in the post-test than they showed in the pre-test ($M_{Pre–Post}$ = -1.08), t (16) = -7.69, $p < 0.001$. There was no correlation between two tests (r = 0.12, p = 0.648). That is, it is not possible to say that the students whose scores were high in the pre-test had high scores in the post-test.

Each student's physics epistemological beliefs in four dimensions and their knowledge level before and after the instruction are shown in Table 2. While, 65% of the students raised their learning to compatible sketchy level after the instruction, 18% of them were able to reached compatible elaborate level. Although 12% of the students (Student 10 and Student 14) kept their compatible / incompatible knowledge level in the post-test, there was an increase in their scores. On the other hand, Student 11 (5%) did not change his knowledge level and decreased his post-test score by two points. However, his knowledge level had already been high and concurred to compatible sketch level. These findings illustrate that conceptual change process occurred and almost all of the students somehow repaired their misconceptions.

Findings with regards to the students' high level epistemological beliefs in the domain of physics and their knowledge gain direct us to the positive relationship between domain-specific epistemological beliefs and learning within the same domain. Mason (2002) explains this relationship as follows: Students having sophisticated beliefs about the nature and acquisition of knowledge can develop and refine thinking dispositions crucial to fostering learning through knowledge revision. Results of this study are consistent with the results of other studies (May & Etkina, 2002; Songer & Linn, 1991; Stathopoulou & Vosniadou, 2007).

Most of the students' physics epistemological beliefs in the dimension of quick learning were close to the advanced level. Likewise, most of the students increased their learning after the instruction. On the other hand, none of the students' physics epistemological beliefs in the dimension of simplicity of knowledge were in advanced level. Furthermore, two of the students had unsophisticated beliefs in this dimension. Similarly, most of the students could not improve their knowledge to the highest level i.e. compatible elaborate level in the questions required them to do analysis. Consequently, students' physics related epistemological beliefs in the dimensions of quick learning and simplicity of knowledge may be good predictors in their conceptual change process in physics. Students with beliefs in gradual learning may study more to reach their learning goals. Students who view physics knowledge as a complex system of organized and re-organized theoretical concepts may think critically and consider alternative views (Stathopoulou & Vosniadou, 2007). Thus, students having sophisticated beliefs in the dimensions of quick learning and simplicity of knowledge are likely to be successful in knowledge acquisition. Qian and Alvermann (1995) found the parallel result regarding general epistemological beliefs.

Table 2. *Epistemological beliefs in the domain of physics and knowledge levels before and after the instruction*

S.	**Simplicity of Knowledge**	**Certainty of Knowledge**	**Innate Ability**	**Quick Learning**	**K. L. in the Pre-Test**	**Score in the Pre-Test**	**K. L. in the Post-Test**	**Score in the Post-Test**	**Conceptual Change**
1	M	H	H	H	IS	22	CS	45	+
2	M	M	M	H	CI	33	CS	44	+
3	H	H	VH	H	CI	32	CS	49	+
4	H	VH	H	H	CI	37	CS	48	+
5	M	H	H	H	CI	32	CS	51	+
6	M	M	H	H	CI	33	CE	53	+
7	H	H	H	M	CI	35	CS	50	+
8	H	M	H	H	CI	38	CS	41	+
9	H	H	M	VH	CI	32	CE	53	+
10	L	M	H	H	CI	32	CI	39	+
11	H	H	H	H	CS	46	CS	44	-
12	M	M	L	H	CI	30	CS	43	+
13	H	M	H	H	IS	24	CS	41	+
14	H	H	H	H	CI	31	CI	35	+
15	H	H	H	H	CI	27	CS	50	+
16	H	H	M	H	CI	27	CS	41	+
17	L	H	H	H	CI	34	CE	56	+

S.: Student, K. L.: Knowledge Level, L: Low, M: Medium, H: High, VH: Very High, IS: Incompatible Sketchy, CI: Compatible Incompatible, CS: Compatible Sketchy, CE: Compatible Elaborate, +: Knowledge gain between pre- and post-tests, -: No knowledge gain between pre- and post-tests

CONCLUSIONS AND IMPLICATION

The following conclusions can be drawn from the study. First, high school students' level of epistemological beliefs in the domain of physics is very close to sophistication. Second, there is a positive association between the students' physics epistemological beliefs and their learning gains. Third, sophisticated domain-specific epistemological beliefs especially in the dimensions of simplicity of knowledge and quick learning are prerequisite for conceptual change.

This current study would contribute to the literature toward a better understanding of the relationship between beliefs and learning by using qualitative research methods.

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ITS CHEMISTRY! AN INTERVENTION PROGRAMME AIMED AT DEVELOPING THINKING SKILLS IN CHEMISTRY

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Abstract: '*ITS Chemistry'* is an intervention programme aimed at developing the thinking skills of Irish second level Chemistry pupils. It also aims to address the chemical misconceptions pupils possess about fundamental Chemistry topics, while also attempting to make abstract topics, such as the Particulate Nature of Matter (PNM) and the Mole, more concrete and tangible for the learner. This programme infuses strategies and methodologies, which have been shown in Chemistry Education Research to be successful in developing thinking skills and understanding, into the established Leaving Certificate Chemistry syllabus. This paper outlines the development, implementation and evaluation of the *'ITS Chemistry'* intervention programme. Results indicate that this programme produced positive effects both on the pupils' cognitive development and also on their performance in a chemical misconceptions test.

Keywords: second level chemical education, chemical misconceptions, particulate nature of matter, the mole concept, cognitive development.

BACKGROUND

This paper reports the results of phase 3 of a project looking at the difficulties in the learning of Chemistry in the Irish school system. In phase 1 the main problem areas/topics in Chemistry were determined for Irish second-level Chemistry pupils and university level students. (Childs and Sheehan, 2009b). Phase 2 investigated the cognitive levels that pupils/students were operating at and the numbers and types of chemical misconceptions they possessed about fundamental topics in Chemistry (Sheehan and Childs, 2011).

Chemistry is known to be one of the most difficult and conceptually challenging subjects on the school curriculum. Many factors contribute to its difficulty and much work has been carried out in attempting to make the content of this subject more accessible. Chemistry by its nature is abstract and requires formal operational thought and contains many higher order chemical and mathematical concepts; thus anyone not operating at this level of cognitive development will have difficulty with Chemistry. Chiappetta (1976) concluded after studying a number of investigations '*that most adolescents and young adults have not attained the formal operational stage of cognitive development*'. In Ireland, it has been found that approximately 8.7% of Junior Certificate pupils (~16 years of age) and 17.7% of Leaving Certificate (LC) Chemistry pupils (~18 years of age) have reached the formal operational stage (Childs and Sheehan, 2009a). The fact that the majority of Irish pupils studying Chemistry at school are still operating at the concrete level may explain the difficulties many pupils have with Chemistry.

Chemical misconceptions are another reason why pupils find particular topics in Chemistry difficult. The chemical misconceptions pupils have will have a major effect on the learning and understanding of advanced topics in Chemistry. Ausubel (1978) stated that if he '*had to reduce all of educational psychology to just one principle, he would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly'.*

Results of misconceptions tests carried out on Irish Junior and Leaving Certificate Chemistry pupils indicate that they possess a large number of misconceptions relating to PNM and the Mole. (Sheehan and Childs, 2011)

RATIONALE FOR THE DEVELOPMENT OF THIS INTERVENTION PROGRAMME

Many intervention programmes have been developed which have aimed to enhance pupils' thinking skills; these include: the Instrumental Enrichment Approach (I.E), Philosophy for Children (P4C), Cognitive Acceleration (CA) and the Infusion Approach. The Cognitive Acceleration through Science Education (CASE) programme has been credited with producing large cognitive development gains for participants. The CASE programme materials, *'Thinking Science',* introduced and developed formal operational thinking patterns over two years with a large cohort of UK children (Dickson, T., 2004). There are problems introducing this into the Irish classroom and consequently our programme was developed using an infusion approach, working within the constraints of the Irish Chemistry syllabus. '*ITS Chemistry*' stands for 'Increasing Thinking Skills in Chemistry'. It was influenced by successful strategies and methodologies used in developing the thinking skills of pupils but infused these into the current LC Chemistry syllabus; it also addresses chemical misconceptions and tries to alleviate difficulties pupils are having with Chemistry, while still achieving the syllabus aims and objectives.

METHODOLGY

Prior to the development of the resource package used in this intervention programme, a number of tasks had to be carried out:

1. A Cognitive Analysis Taxonomy (CAT) was carried out on the topics to be included in the intervention programme in order to develop a logical progression through the lessons.
2. A list of chemical misconceptions, relating to the topics included in the intervention programme, was constructed in order to alert teachers to their presence.
3. The LC Chemistry syllabus was analysed to ensure the intervention programme was covering the syllabus.

This intervention programme was developed for pupils who had just completed their JC Science examination and who had chosen to study LC Chemistry. The intervention covered the initial 12 weeks of the course and was based on the following research findings:

- Results of phase 1 showed that pupils were having difficulty with abstract Chemistry topics that would require formal operational thinking;
- Results from phase 2 of the showed that the majority of Irish JC Science and LC Chemistry were operating at the concrete operational stage, making it difficult for them to tackle abstract topics;
- Results of phase 2 also indicated that JC and LC pupils possess a large number of chemical misconceptions about fundamental Chemistry topics.

The topics chosen to be covered as part of the intervention programme were the Particulate Nature of Matter (PNM) and the Mole Concept for the following reasons:

- Previous investigations (Childs and Sheehan, 2009b) have shown that the Mole and calculations involving the Mole are perceived by pupils as being difficult;
- The Particulate Nature of Matter was identified as an topic in which pupils possessed many misconceptions;
- These topics have been described as threshold topics (Meyer and Land, 2003), which are important if a pupil is to understand more difficult Chemistry topics later in the course;
- These topics are covered at the start of the LC Chemistry course.

Figure 1 outlines the content of the 12 week *'ITS Chemistry'* programme.

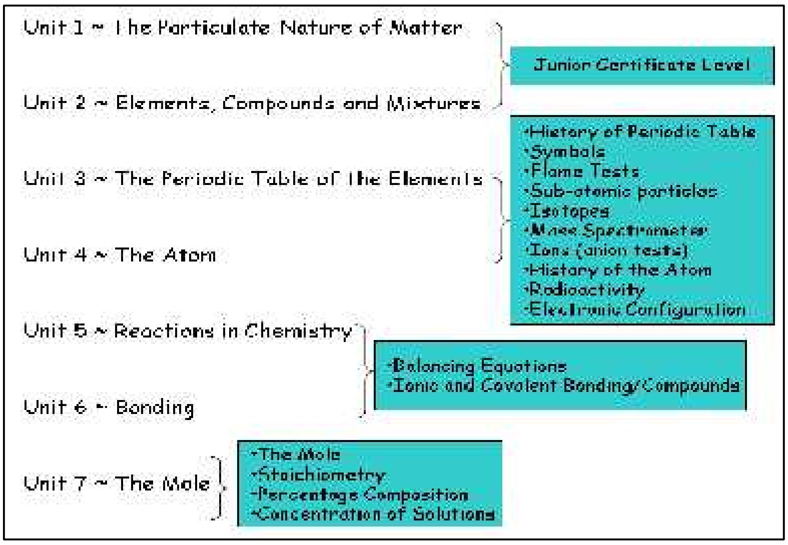

Figure 1: Structure and content of the 'ITS Chemistry' intervention programme

Figure 2 outlines the different areas of Chemistry Education Research that inspired and shaped this intervention programme.

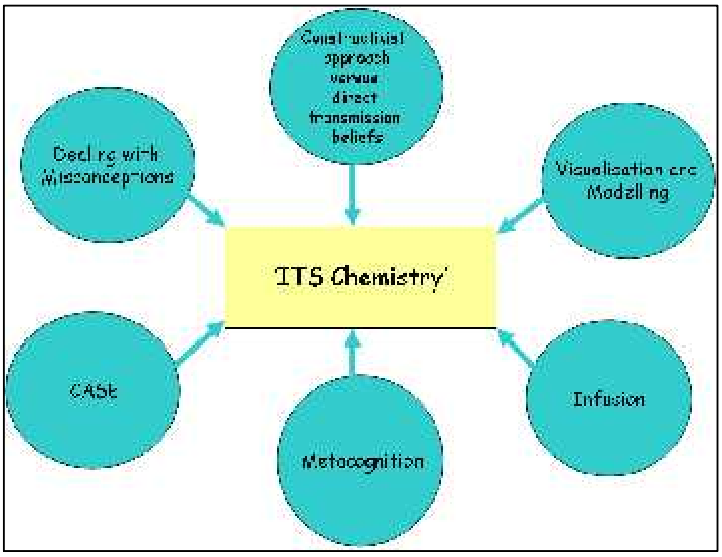

Figure 2: Areas of educational research that inspired the development of 'ITS Chemistry'

Successful strategies were identified from the different areas listed in Figure 2 and were infused into the current LC Chemistry syllabus for the Particulate Nature of Matter and the Mole concept. Using the infusion approach means there is not only an enrichment in content and learning experiences, but also there is no loss of time in covering the syllabus, making it attractive to the teachers.

The *'ITS Chemistry'* intervention programme paid particular attention to the introduction of topics through concrete exercises, along with cognitive conflict and the social interaction aspects of the CASE lessons. These approaches not only promote the development of cognitive ability, but they effective in addressing and reduce pupils' chemical misconceptions. The structure and key design features of a typical '*ITS Chemistry'* lesson are shown in Figure 3.

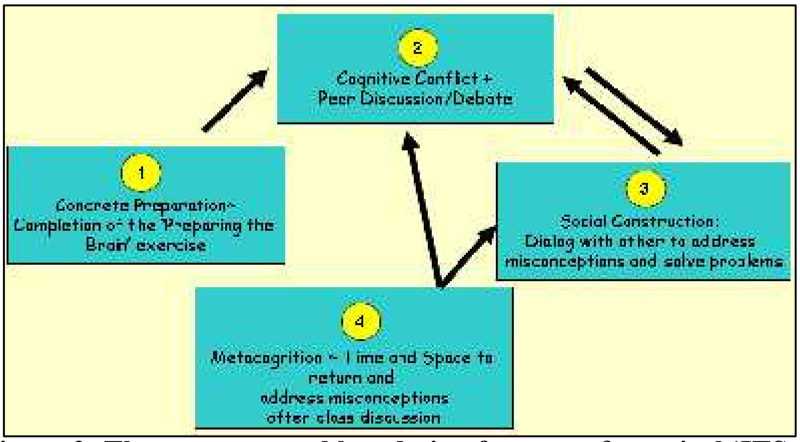

Figure 3: The structure and key design features of a typical 'ITS Chemistry' lesson

Each '*ITS Chemistry'* lesson began with a revision of previous ideas and with an explanation of terms and description of equipment that the pupils would be using during the lesson, and this section in the pupils' handbook was titled *'preparing the brain'* and focused pupils on what coming next. Figure 4 illustrates an example of a *'preparing the brain'* activity.

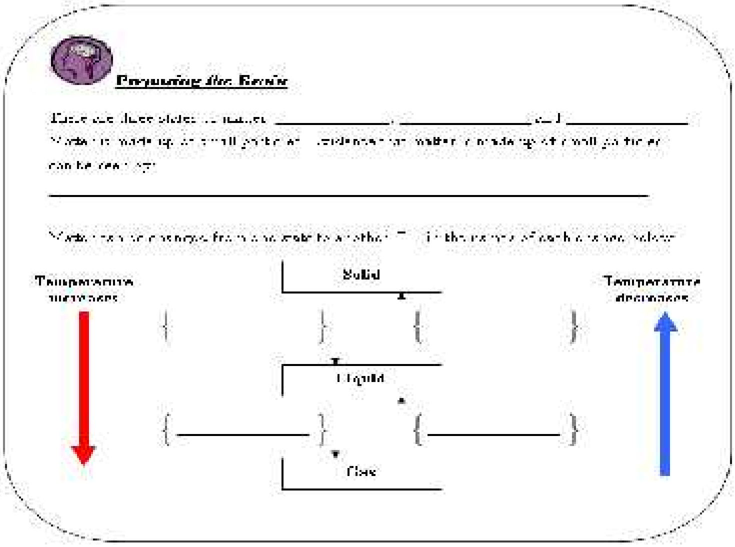

Figure 4: Example of a 'preparing the brain' activity which appeared at the beginning of each of the ITS Chemistry lessons

Lessons also included practical, hands-on activities and tasks focused around social interaction between pupils. They were used to provide pupils with an opportunity to discuss what was happening and why. Cognitive conflict was initiated as a result of social interaction and teacher intervention and was done through group and teacher-led discussion. Discussion of ideas and concepts also play an important role in the identification and altering of chemical misconceptions. While many philosophies of thinking influenced the *ITS Chemistry* programme, it is in fact an infusion approach aiming to develop thinking skills both *within* and *through* the course content. Metacognition was encouraged in this intervention programme by allocating time in the lesson and space in the Pupils' Workbook to return and correct answers to questions. In the homework exercises pupils completed activities relating to those studied in class and were encouraged to explain their answers.

The teachers taking part in the implementation of this programme received training at the start of the school term, and the theoretical background covered was also included in the Teacher's Handbook. The cognitive development of pupils was assessed at the start of the programme using Science Reasoning Task Three. After completing the 12 week programme they completed a post-

test: this took the form of another Science Reasoning Task and also a chemical misconceptions test; these reasoning scores were compared with the pre-test scores. Cognitive development and the types and numbers of misconceptions of the experimental group were compared with a control group, who covered the same material in the traditional way. The teachers' views were collected through a teacher's diary and a short questionnaire at the end of the project.
The research questions to be answered by this investigation are as follows:

1. Can cognitive acceleration be achieved through infusing a cognitive acceleration technique into the normal Irish Chemistry syllabus?
2. Can chemical misconceptions be addressed at the start of the LC Chemistry course and thus alleviate difficulties pupils have with crucial Chemistry topics?
3. Does this research-based teaching strategy increase pupils' understanding of the Particulate Nature of Matter and the Mole?

Table 1: Profile of the experimental group that participated in phase 3 of this investigation

	Profile of Experimental group for phase three of this investigation (n= 93)
Age Profile	15 Years Old = 24.7% 16 Tears Old = 71.0% 17 Years Old = 2.2% Missing = 2.2%
Gender Profile	Male = 42 (45.2%) Female = 51(54.8%)
Breakdown of pupils' Mathematics level for the Junior Certificate Examination	Higher Level = 54 (58.1%) Ordinary Level = 37 (39.8%)
Breakdown of pupils' Science level for the Junior Certificate Examination	Higher Level = 77 (82.8%) Ordinary Level = 14 (15.1%)

In total 5 schools (6 different class groups, 93 pupils) trialled the '*ITS Chemistry'* intervention programme., one of which was the school of one of the researchers (MS). The profile of the experimental group involved in the implementation of the ITS Chemistry programme is given in Table 1.

Table 2: Profile of the control group that participated in phase 3 of this investigation

	Profile of the control group for phase three of this investigation (n= 57)
Age Profile	15 Years Old = 17.5% 16 Tears Old = 50.9% 17 Years Old = 26.3% Missing = 5.3%
Gender Profile	Male = 38 (66.7%) Female = 19 (33.3%)
Breakdown of pupils' Mathematics level for the Junior Certificate Examination	Higher Level = 41 (71.9%) Ordinary Level = 13 (22.8%)
Breakdown of pupils' Science level for the Junior Certificate Examination	Higher Level = 54 (94.7%) Ordinary Level = 3 (5.3%)

Table 2 shows the profile of the control group (4 schools, 57 pupils) used in this investigation. It is important to note that a higher percentage of the control group took the more difficult higher level examination in Science for the Junior Certificate than the experimental group. This may indicate that the control group are initially stronger in Science than the experimental group.

RESULTS AND CONCLUSIONS

Results from this intervention programme indicate a positive effect of participation in the '*ITS Chemistry'* programme on their performance in a chemical misconceptions test. Figure 5 shows the experimental group's performance compared to the control group. Both groups had covered the same Chemistry content.

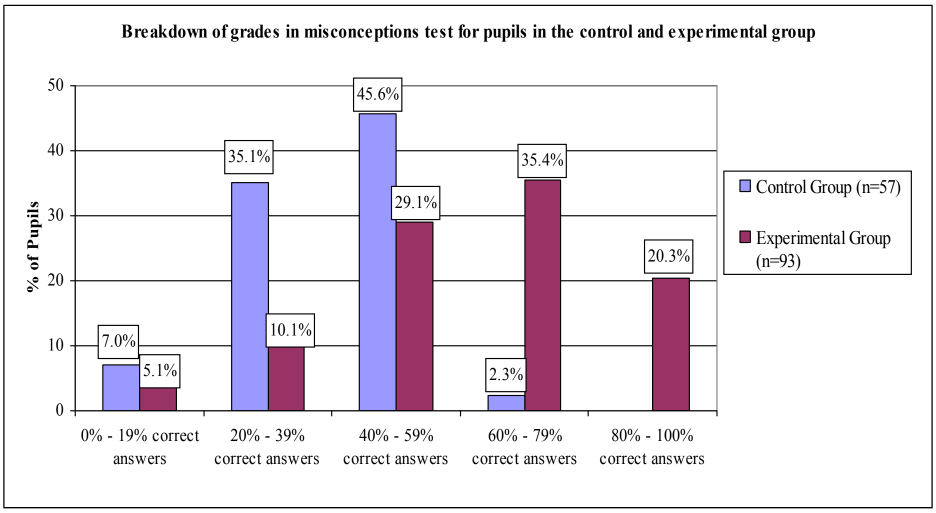

Figure 5: Comparison of results for the chemical misconceptions test for the control and experimental group

The results show that the experimental group performed better in the chemical misconceptions test than the control group. This is an encouraging finding, considering that pupils in the control group were stronger at Science initially than those in the experimental group. Overall 42.1% of the control group scored less than 40% in the chemical misconceptions test, compared to 15.2% of pupils from the experimental group; 20.3% of the pupils in the experimental group achieved more than 80% in the test; whereas no pupil from the control group scored above 80%.

The intervention programme also had a positive effect on the cognitive level of the experimental group. Figure 6 shows the summary of the changes in cognitive levels after participation in the intervention programme for the experimental group.

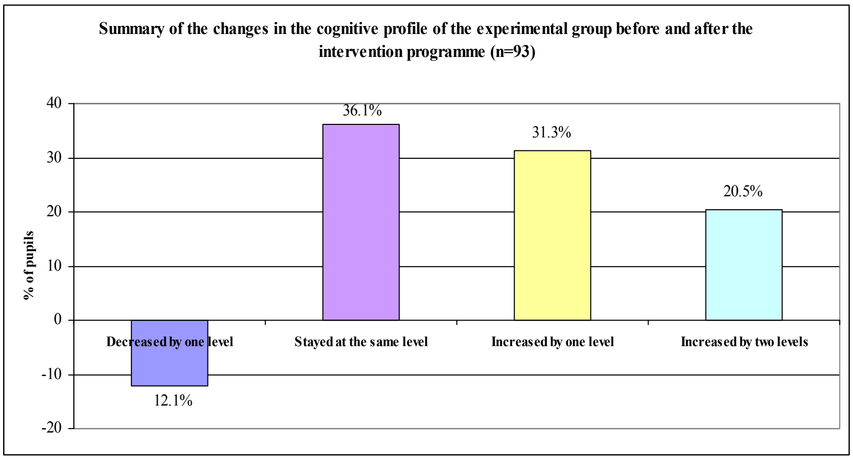

Figure 6: Summary of the changes in cognitive levels after participation in the intervention programme

The results indicate positive effects on the pupils' cognitive development after participation in the '*ITS Chemistry'* intervention programme: 51.8% increased their cognitive level.

The initial results from this intervention programme indicate that it is indeed possible to improve the thinking skills of pupils, through an infusion of different teaching methodologies into the Irish LC Chemistry syllabus. This short intervention (12 weeks) increased the percentage of pupils operating at the formal level of cognitive development compared to their initial level, and the percentage of the experimental group operating this level significantly exceeded that of control group and the LC cohort previously studied, indicating the potential of this approach to raise cognitive levels. There is no doubt that *'ITS Chemistry'* has also been successful in addressing the chemical misconceptions possessed by pupils.

This intervention project has shown that it is possible to develop lessons to include research-based methodologies without interfering with the delivery of the prescribed syllabus. The approach taken in this intervention programme should be applied to the whole LC Chemistry syllabus, and this might help to alleviate the difficulties pupils currently have with many Chemistry topics. The positive effects shown on both the cognitive ability and reduction of chemical misconceptions in this short intervention project suggest that using this approach for the whole course would have very significant results.

Since the research was completed (in May 2010) the authors have had the opportunity to disseminate the ideas and materials to teachers in several workshops. The ideas and teaching materials have been well received and it is intended to continue to disseminate the materials and encourage their use. It is also intended to compare the examination results in Chemistry for the experimental and control groups at the end of their LC course (in June 2011), in order to see if the intervention programme had a long-term effect on pupils' performance.

We believe that 'ITS Chemistry' has demonstrated the value of using the findings of Chemistry Education Research to change the way Chemistry is taught in schools, in order to produce more effective learning and deeper understanding of the subject.

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INVOLVING STUDENTS IN RESEARCH ON THE USE AND CONSTRUCTION OF CONCEPT CARTOONS FOR CHEMISTRY CLASSES

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Abstract: A student-scientist partnership is presented where students and their teachers are involved in science educational research on the use and conceptual design of Concept Cartoons. The purpose of the ongoing collaborative research is twofold: First, the use of Concept Cartoons in chemistry education shall be investigated and improved. Second, the students get the opportunity to engage in authentic research, and the learning outcome associated with the research apprenticeship is explored.

At the participating schools students were trained to interview younger students in order to identify their pre-conceptions. Using these beliefs, they have created Concept Cartoons that will be used and evaluated in class in the course of the second year of the project.

The paper focuses on the participant perceptions of the student-scientist partnership. The data source consists mainly of the students' self-reports. Preliminary results suggest that the students have benefitted from their involvement in the research project in terms of scientific content knowledge, skills, confidence and self-efficacy, intellectual development, satisfaction and discourse practices.

*Keywords***:** research apprenticeship, student-scientist partnership, Concept Cartoons, learning outcome

INTRODUCTION

Student research apprenticeships offering learners opportunities to engage in authentic scientific inquiry have become increasingly popular over the past few decades. At secondary level these apprenticeships are organized either as extra-curricular programs or as classroom-based student-scientist partnerships (SSP). Much research has been done on the learning outcomes associated with participation in research apprenticeships (Sadler, Burgin, McKinney & Ponjuan, 2010). The Austrian Federal Ministry for Science and Research runs a program called "**Sparkling Science**"[1], in which scientists are asked to do research in collaboration with students and teachers. The intention is to break down structural barriers between school and university for the benefit of both.

The research project presented in this paper is supported by "Sparkling Science". Its objectives are to investigate and improve the use of Concept Cartoons in chemistry education together with upper secondary students and their teachers. At the same time we want to explore the students´ benefits from the collaborative research project. Different to most SSP-projects, where the researchers are chemists, biologists etc., in this case the researchers

[1] http://www.sparklingscience.at/en/

involved are educational researchers. In this paper we concentrate on the benefits students gain through this partnership.

Based on constructivism, Concept Cartoons were first developed in the 1990s by Keogh and Naylor (1999). They were primarily intended as a teaching and learning aid and are frequently used as a surveying method to identify learners´ alternative conceptions. The cartoons show students in everyday situations discussing a scientific topic. Both scientifically acceptable viewpoints and alternative conceptions are shown in speech balloons. The students are asked to comment on these statements, and to use their existing knowledge to describe their own assumptions regarding the main question of the cartoon. Contrary to a multiple-choice test item, the task is not to find “the right answer” in one of the speech balloons but to question ways of thinking and to argue about the ideas. Thus students’ conceptions will become visible and debatable, and first steps towards conceptual growth or change can be taken (Stenzel & Eilks, 2005; Treagust & Duit, 2008). Furthermore, Concept Cartoons can be used to promote students’ argumentation in science (Chin & Teou, 2009; De Lange, 2009). Teaching and learning argumentation in a scientific context facilitates lifelong learning of science-related issues as well as participation in social issues (Osborne, Erduran, & Simon, 2004). In addition, we assume that using Concept Cartoons is a promising tool to initiate comprehensible learning (Lembens & Steininger, 2011).

The project involving three secondary schools in Vienna and Graz (Austria) started in September 2010 and will end in August 2012. At the beginning, the secondary school teachers used Concept Cartoons specially designed for their needs in accordance with the curriculum. After becoming acquainted with Concept Cartoons upper secondary school students were introduced to learning theories, constructivism and the importance of students´ conceptions for successful and sustainable learning. Additionally, they received training in interview techniques and learned how to design Concept Cartoons. Equipped with these competencies they interviewed lower secondary school students in order to find out their conceptions of selected topics concerning acids and bases. After analyzing and interpreting the interview records in collaboration with the educational researchers, the upper secondary school students designed Concept Cartoons incorporating the interviewees’ beliefs. In an iterative process these Concept Cartoons will be used and tested by the teachers in a lower secondary class, while the upper secondary school students will support the younger students during their group discussions focussing on the topic presented by the newly designed Concept Cartoons.

AIM/RESEARCH QUESTION

In general, a student-scientist partnership is a collaboration between a scientist or group of scientists, the students of one or more classes and their teacher(s) who all work together on a topic or question commonly originating from the scientists´ recent field of research. The students´ learning outcome and the quality of their involvement are of interest for science educational researchers, who look at this from outside as they are not part of the authentic scientific inquiry the student-scientist partnership is about.

In this project the structure is slightly different. Students themselves are involved in science educational research. The object of research is the use and construction of Concept Cartoons for chemistry classes. The science education researchers are at the same time both part of the student-scientist partnerships and evaluating the students´ benefit.

In this paper we deal with the following research question: How do the students benefit from the collaborative research project "Comprehensive Learning through Concept Cartoons"? To subdivide this general question into different aspects we use categories presented by Sadler et al. (2010), such as scientific content knowledge, skills, confidence and self-efficacy, intellectual development, satisfaction and discourse practices.

METHODS

To assess the learning outcome initiated through the involvement in the research project on Concept Cartoons, both quantitative and mainly qualitative research instruments have been applied.

At the beginning the upper secondary school students filled in a questionnaire (five-level Likert-type scale) on their chemical self-concept and their motivation in learning chemistry. For both, existing instruments were adapted (Dickhäuser, Schöne, Spinath & Stiensmeier-Pelster, 2002; Müller, Hanfstingl & Andreitz, 2007).

At the same time teachers completed an open-ended questionnaire on their expectations of the collaborative project and their experience in dealing with students' conceptions and argumentation in science classes. Following the approach of participatory action research (Altrichter & Posch, 2007), the teachers were asked to document their experiences by keeping a research diary.

At each school 2- to 4-hour-long "project lessons" were audio- and videotaped three to five times, additional field notes were taken as well.

At the end of the first year of collaboration the students were asked to write reflective papers documenting their experiences made so far, and semi-structured interviews were conducted with the three teachers.

All qualitative data has been and will be evaluated using content analysis following Mayring (2007).

RESULTS

As the project is still on-going, the presented results are preliminary.

Quantitative Data

The statistical evaluation of the students´ questionnaires shows that the classes at school 1 and school 3 are quite similar in terms of motivation in learning chemistry. Students at school 2 achieve lower results. A value of -12 indicates exclusively extrinsic motivation whereas +12 means entirely intrinsic motivation.

Descriptive statistics of students´ motivation measured as self-determination index (SDI)						
School No.	**sex**	**N**	**min**	**max**	**M**	**SD**

school 1	girls	12	-5.35	4.20	**0.98**	3.00
	boys	11	-0.65	10.60	**3.58**	3.73
school 2	girls	10	-2.80	8.25	**1.51**	3.88
	boys	5	-3.75	4.95	**-1.28**	3.63
school 3	girls	8	-4.70	5.70	**0.66**	3.87
	boys	19	-4.00	11.10	**3.06**	4.04

Table 1: Descriptive statistics of students´ motivation measured as self-determination index (SDI)

At schools 1 and 3 the boys seem to be more intrinsically motivated than the girls whereas at school 2 the situation is quite the opposite.

Descriptive statistics of students´ chemistry self-concept						
School No.	**sex**	**N**	**min**	**max**	**M**	**SD**
school 1	girls	13	10	19	**14.15**	3.18
	boys	14	7	25	**17.29**	4.80
school 2	girls	10	11	24	**17.40**	3.57
	boys	6	12	19	**15.83**	2.93
school 3	girls	8	7	20	**12.75**	3.85
	boys	19	9	24	**16.79**	4.59

Table 2: Descriptive statistics of students´ chemistry self-concept

The differences regarding the students´ chemistry-related self-concept are smaller but point into the same direction. The minimum score of 5 indicates a very low, the maximum of 25 a very high chemistry self-concept.

At the end of the project the same questionnaire will be applied in order to see if there is any change in the students´ motivation and/or self-concept.

Qualitative Data

Sadler et al. (2010) classify the possible learning outcomes of apprenticeship programs amongst others in terms of scientific content knowledge, skills, confidence and self-efficacy, intellectual development, satisfaction and discourse practices.

Regarding *scientific content knowledge* the project is highly interdisciplinary. Of course, students had and have the opportunity to broaden their understanding of chemistry in general, and of acids and bases in particular. The majority of them report that they have the feeling of having learned a lot concerning this matter. One student explained this as follows:

Student 6: “It was a good way of giving us an understanding of acids and bases. Otherwise I wouldn't have looked into it so deeply. Because of the preparation of the interviews the subject became more concrete and less alien.”

But at the same time the students also got to know some aspects of didactic and social sciences, topics that are not normally taught at school. More than three quarters of them described conducting the interview as being beneficial.

Student 22: *"*Above all I found conducting an interview an extremely helpful learning progress. We will probably need these skills quite often in the future but they are not easy to learn. […] It was an important experience to assess one's interviewee and to adjust oneself regarding language and content."

When preparing the interviews many students had expressed their fears of whether the lower secondary pupils would take the task seriously and how they themselves would manage their new role. Afterwards, most of them were pleased and proudly reported on their experience. This is an example of how the learning opportunity contributed to increasing the students´ *self-confidence*.

The students´ reflective papers also account for various *skills* of different categories (Sadler et al., 2010) the students worked on. For example, a student described the research process they went through to collect and analyse the data:

Student 1: "We first had to develop the guidelines for the interview and then interview two groups of pupils. It was not always easy to gain concrete and useful conceptions from the pupils' answers."

Another one depicts the teamwork as challenging:

Student 7: "I once again noticed how difficult it is to work as a group. The group members don't necessarily like each other. Therefore it is even more difficult to get organized as they aren't motivated."

There are also passages in the papers that indicate *intellectual development*. For example, one student reflected on his/her own work attitude and how it was influenced by the project:

Student 7: "We noticed that we didn't have a clue of what we were talking about [acids and bases]. That's how I learned to really involve myself in a topic before working with it."

A teacher pointed out during the interview that the students´ black-and-white thinking was challenged by their work on the Concept Cartoons.

Teacher 2: "One thing the students acknowledged was that they became aware that statements are not always either right or wrong, but some have to be discussed."

As Concept Cartoons are developed to promote argumentation and *discourse practice* in science education, working in a project on Concept Cartoons provides an opportunity to gain experience and skills in these fields.

Unlike extra-curricular apprenticeship programs, student-scientist partnerships work with all students of a class including also the less interested and less talented. That is why *engagement* and *satisfaction* – two factors quite dependent on each other – are crucial. Satisfaction relies on success and success relies on engagement. In accordance with their different general attitudes towards chemistry learning at school, the students´ commitment varied.

Nevertheless, all three teachers noted that some students definitely engaged more than they usually do.

Teacher 2: "Especially those students who are less talented regarding chemistry turned out to be really good in drawing or in meticulously transliterating the interviews. They knew that this is the way to show what they are able to do."

A student reported:

Student 13: "We were able to fulfill the expectations of the project managers because we worked as a group and did not give up even though we had to overcome many obstacles."

The notions that the effort was worthwhile and that the students took pride in their work can be found in the following quote, which is representative of several:

Student 9: "To finally draw the Concept Cartoons was the best and most joyful part of the whole project, maybe partly because we realized what all the work was for. I am very content with the final result!"

CONCLUSIONS AND IMPLICATIONS

The data available half way through the project allows preliminary results and conclusions. These highly rely on the self-reports of the participants, a fact generally criticised by Sadler et al. (2010). Nevertheless, the results suggest that the students did benefit from their involvement in the research on the use and construction of Concept Cartoons for chemistry classes in various ways.

Many of the statements quoted above can be interpreted as indicating a potential learning progress in more than one category. For example, having successfully "*overcome many obstacles*" (S13) helps to foster self-efficacy. Realizing that "*some statements are not always either right or wrong, but some have to be discussed*" (T2) is a sign of increased understanding of the nature of science (NOS).

The overall impact of the student-scientist partnership cannot be evaluated before the end of the program. On the one hand, further learning opportunities will be offered when the students revise their Concept Cartoons and witness and support their deployment in lower secondary school classes. On the other hand, the post-test questionnaire has to be applied and the results have to be compared with the initial findings. In-depth interviews will be conducted with some of the students, and the teachers´ reports need to be evaluated.

However, apart from gains in various specific domains students most certainly have generally broadened their horizons. The project provides insight into disciplines that are not part of the usual curriculum and thus contributes to breaking down structural barriers between school and university.

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HOMEWORK MOTIVATION AND ACHIEVEMENT IN CHEMISTRY EDUCATION

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Abstract: Based on the assumption that homework effort is a key factor for achievement and affected by motivation, this study investigates the effect of a systematic variation of homework assignments' features namely context (domain specific, non-domain specific), the treatment of experiment (paper-pencil, hands-on), and level of task demands (low, medium, high) on homework motivation in chemistry education. Therefore, assignments are created and subsequently rated by students with regard to value and expectancy beliefs by means of a questionnaire. Then, a study was conducted within which students were given the assignments for homework.

Keywords: homework, expectancy beliefs, value beliefs, effort, quasi-experimental study, chemistry education

FRAMEWORK

Students tend to put a minor effort in doing their homework, probably considering homework a waste of time. Not only students unwilling to do their homework doubt that time investment into homework pays off, but also researchers have not proved a correlation between time spent on homework and achievement, yet. However, a crucial factor for achievement might be homework effort (Schnyder, Niggli, Cathomas, Trautwein, & Lüdtke, 2006) which might be positively affected (Trautwein & Köller, 2003) by aspects of homework motivation such as value and expectancy beliefs (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000).

Most studies on homework are concerned with homework in general and less emphasis is put on domain-specific aspects and behaviour, although it is supposed to differ depending on the subject. However, Trautwein and Lüdtke (2007) have conducted a study focussing on differences in homework effort with respect to different school subjects using scales deriving from a previously developed homework model (Trautwein, Lüdtke, Schnyder, & Niggli, 2006).

Although a variety of differences in homework behaviour have been investigated, homework behaviour has not been subject to a study investigating domain-specific effects in chemistry education, yet. In this work, the effect of homework characteristics (learning environment) on achievement in chemistry education shall be examined. The study is conducted to answer the following research questions:

1. To what extent may homework assignments in chemistry education embedded into different learning environments positively influence students' motivation with regard to value beliefs and expectancy beliefs?

2. What effect does a variation of value beliefs and expectancy beliefs have on achievement?

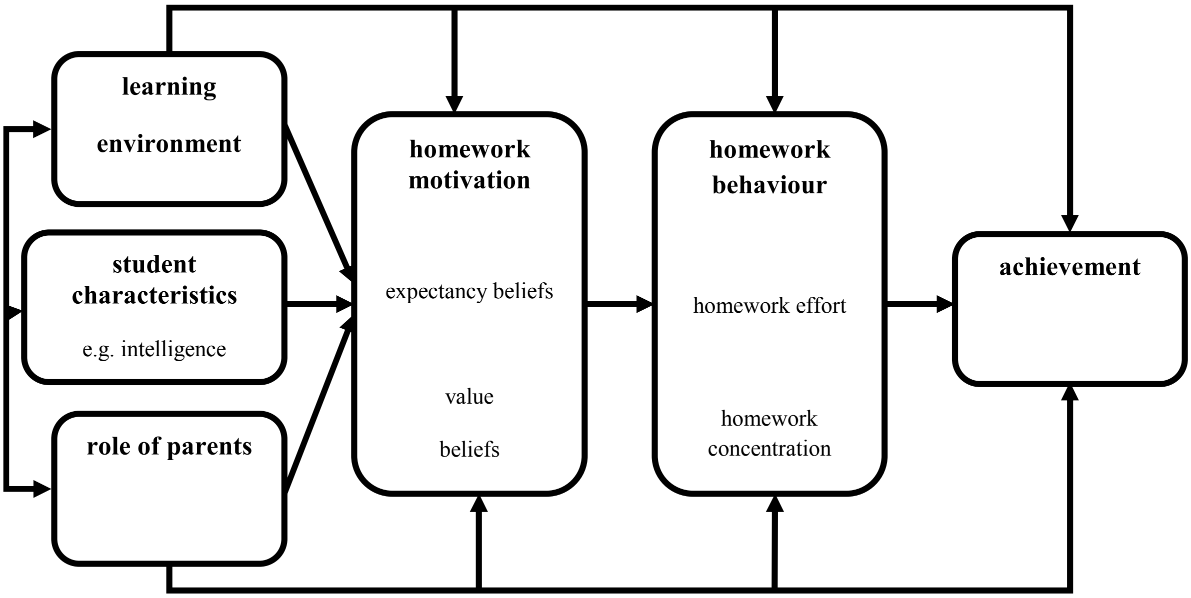

Figure 1: simplified homework model (Trauwein et al., 2006)

METHODS

In order to answer the research questions, the study was conducted in two steps. The first step focuses on answering the first research question. In this phase assignments were created for four lessons out of a sequence of eight lessons and evaluated with regards to motivational aspects. The function of the evaluation was to select assignments to be used in the second phase of the study. The second phase focuses on answering the second research question. In this phase, assignments that are found to differ in students' self-reported value beliefs and expectancy beliefs are given for homework in a course of eight lessons within a framework of a quasi-experimental study. In order to investigate the effect the differences in motivational aspects of the respective assignments have on achievement, achievement data are obtained in a pre-post design.

As situational interest can be increased by contexts perceived relevant by the students (Krapp, 1993, 1999; Krapp & Prenzel 1992; Schiefele, 2001) one of the features being varied is context. Experimental work in general is seen positively (Hofstein, 2004; Hofstein & Lunetta, 2004) and various studies describe that experimental homework is preferred to non-experimental homework (Tiedt, 2006; Vries, Martin, & Paschmann, 2006). Consequently, the assignments created for the four of the eight lessons for the first step of the study vary in (i) context (four non-domain specific contexts, two domain specific contexts = six-fold), (ii) the treatment of experiment (paper-pencil, hands-on = two-fold), and (iii) difficulty (low, medium, high = threefold).

(i) The contexts are generated by stories created for this purpose and narrated formulaically as follows: a protagonist slips into a situation demanding an experiment to be carried out in order to solve a problem.

(ii) To solve the hands-on-experiment assignments an experiment has to be carried out. Accordingly, the paper-pencil variation contains a representation of probable observations and differs from the hands-on-experiment variation in that the represented observation is to be interpreted without carrying out an experiment beforehand. In both cases, the respective observations have to be interpreted and the results are to be evaluated taking the problem to be solved into account.

(iii) The level of difficulty is determined by the complexity of the tasks. It is expected that difficult assignments have a negative effect on expectancy beliefs and assignments perceived as too easy might be considered less worth to be solved.

The resulting 4*6*2*3 = 144 assignments have been rated by a sample of 608 eleventh grade students. Every student has evaluated a set of nine assignments differing in context, treatment of experiments, difficulty level and lesson. Therefore, the questionnaires developed and successfully used by Trautwein et al. (2006, 2007) were adapted for the purpose of rating the particular assignments. To score the respective items, a 4-point Likert-type scale is used ranging from total agreement (1) to total disagreement (4).

The next step was to experimentally investigate whether homework motivation, and thus homework effort and achievement are affected by the characteristics of the homework given. Students were provided with the previously created and rated homework in the course of a sequence of eight lessons. While half the students were given homework containing rather positively rated assignments (intervention group), the other half (control group) received rather negatively rated homework instead. Additionally, the intervention group were offered a choice of homework in the second half of the course in order to examine the effect of choice on achievement. Since deciding between homework offers evokes the feeling of autonomy, a positive effect on the learning progress is anticipated on the grounds of self-determination theory (Deci & Ryan, 2000).

PRELIMINARY RESULTS

Investigating the resulting data set using ANOVA no significant differences between the respective levels of difficulties as well as between the treatments of experiment could be detected. According to the calculated estimated means, the most positively rated context regarding expectancy beliefs is the party context (1.74), while the most positively rated context regarding value beliefs is sports (2.29). However, the most negatively rated context regarding expectancy beliefs (1.90) as well as value beliefs (2.35) is the domain-specific context with a laboratory worker being the protagonist. With regard to context there is a linear contrast between the contexts party and laboratory ($T(138)=-2.263$ ($p<.05$)).

However, assignments including stoichiometric calculations seem to have the strongest effect on motivation ($F(3,140)=45.29$; $p<.01$) and expectancy beliefs are significantly lower, for assignments that require calculations to be performed than for assignment without calculations (linear contrast $T(140)=10.372$; $p<.01$).

Hence, the control group was provided with homework assignments having a laboratory worker as protagonist, while the intervention group was assigned homework with party context. Homework assignments having sports as context were used in the second part of the intervention in which the intervention group was provided with a choice of 4 assignments for each lesson. In the intervention study, the assignments of the control group as well as the assignments of the intervention group were rated similar to the exploration study. Still another similarity between students participating in the intervention study and the exploration study is the extent to which they report to put an effort in doing their homework for chemistry in general and also for the subjects English, mathematics and physics. Across all subjects, the reported effort correlates with expectancy beliefs ($.392 < r < .494$; $p < .05$) as well as with value beliefs ($.450 < r < 495$; $p < .05$). A t-test for independent samples shows a difference in the effort reported for chemistry compared to physics with chemistry being the subject with higher efforts reported ($t(873)=2.374$; $p < .05$). In both studies, the parents are more involved in the homework process when homework is for English or mathematics, although parents of eleventh grade students are less involved in the homework process than parents of ninth grade students, when students do their homework for chemistry ($t(770{,}589)=-2{,}254$; $p<.05$), English ($t(741{,}205)=-4{,}766$; $p<.05$) and mathematics ($t(754{,}871)=-2{,}574$; $p<.05$).

CONCLUSIONS

On the whole, the homework assignments and the homework situations in different subjects are rated similarly in both studies. Also despite of the differences in age, the effort put into homework for English and mathematics is similar, but parental involvement is different. The older the students, the less are the parents involved into doing homework. This finding is well in accordance with previous studies (Kieren, 2008). All in all, the preliminary result are also well in accordance with the underlying homework model (Trautwein et al., 2006)

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THE SECRETS OF OUTDOOR GAMES AND THE LAWS OF KINEMATICS

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Abstract: Outdoor activities can play an essential role in studying physics. The construction of a content and learning environment based on everyday life experiences of students remains an appealing challenge for teachers: a careful and thorough didactical analysis is necessary to put forward each concrete case or teaching module. In this paper an example of designing a case based on a non-traditional set of exercises for traditional kinematical issues is presented. An outdoor game is used as a main resource for coherent content-context designing.

The content components of the case include traditional kinematical issues: “translational and rotational motion”. Usually these issues are not so easy for students and the traditional sets of exercises often look boring or artificially sophisticated for them. One of the ways to overcome this difficulty is to use the well-known traditional games as an element of learning environment. Students’ experience in and inspiration towards some well-known activity games are very important resources. The purpose of this study was to analyze the didactical potential of ancient outdoor games and to work out a non-traditional set of exercises appropriate for organizing individual action-research studies for small groups of students.

Keywords: outdoor activity, kinematics, content-context designing.

Background

During the last decade the interest of students in science education in most developed countries has been falling crucially (Fig.1). In general it’s the result of the great social, cultural and economical changes in modern society despite the fact that in many countries the development of a knowledge based society is declared as a strategic goal (NSB, 2004).

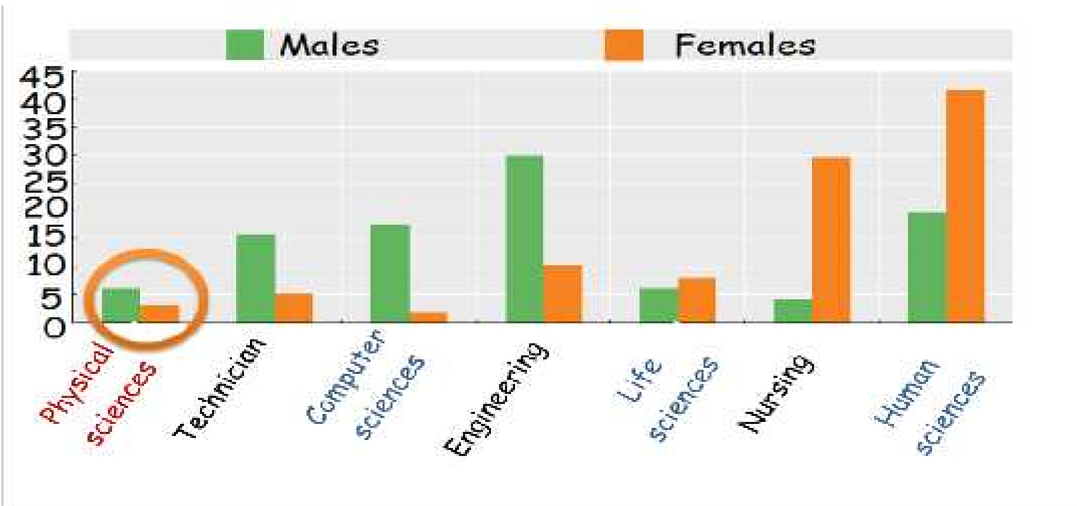

Figure 1

The teachers’ and scientists’ communities make huge efforts to overcome this contradiction, contribute a lot to improve learning environment. In particular, new methods and approaches based on thorough analysis of the context, cultural and psychological aspects of learning were carried out in physics education. On the other hand, the problem of *content* remains actual and challenging too. It is proved by the success of research-based schemes of studies, when content and context interplay actively. Among these schemes teaching science outdoors is of special interest (Popov O., Tevel I., 2007). Within this scheme the teacher has a good opportunity to motivate and encourage students, exploring their natural inspiration towards the investigation of the world of everyday life. Science field experiences can be designed and implemented in "natural" areas and urban environments taking into account cultural and historical traditions. One of the resources, still not exploited in the proper way, is connected with traditional games.

Undoubtedly, most of us – students and teachers – had played outdoor games, at least in the childhood. Usually, you need a very modest "set of equipment" for such games.

For example, the set for the game «Priest», which is very popular in Russia, includes only a stick and tins (Fig. 2). The idea of the game is very simple: to knock off a tin (or several tins) using a stick.

Figure 2

The position of the player is restricted by the sequence of threshold lines. The starting position corresponds to the line, wich is most distant from the target him.

The successive player has the right to shift his/her position to the next threshold (Fig.3). Typically, children try to stand closer to the target, make the throw with more force and try to use a more lengthy stick. But very often all these tricks don't work properly and the stick misses the target.

It appears that this simple game and its secrets are really good material for introducing and careful analyzing the kinematic laws.

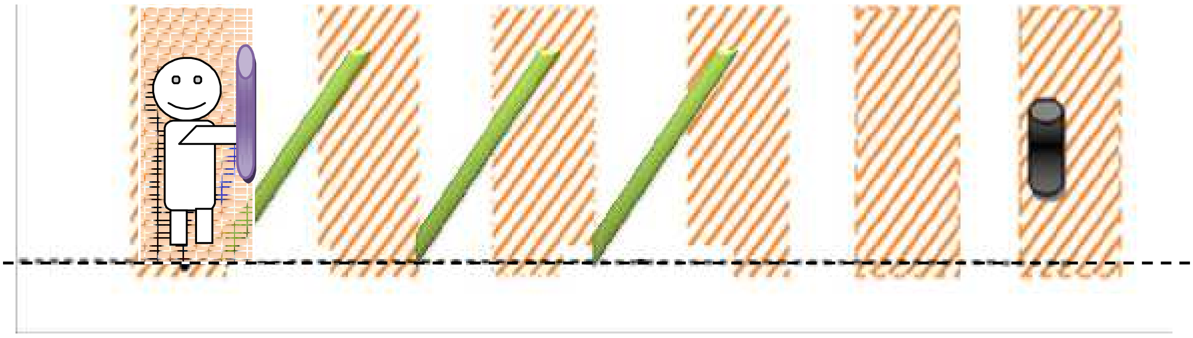

Figure 3

Purpose

The research question was: to analyze the didactical potential of an ancient outdoor game. It is a really hard question - stay in a classroom or go outdoors? It is much more complicated to go outdoors with a class. A teacher must think about a place and equipment, about students' safety, about organization of students' work, because students could just play a game without any reflection. And it could be rainy or windy, etc. So the question is: does a teacher need to make the lesson much more complicated? We decided to risk and go outdoors.

Course design

The course design included three steps:

* Classroom learning. Teacher' explanations, theoretical background.
* Outdoors activities. The students went out door and tried to use different techniques of stick throwing.
* Classroom discussion. Deriving conclusions.

Participants

The investigation was made in the spring of 2011. The target group was the first and the third year students from the department of physics and mathematics.

Methods of the investigation

In the investigation we used both a qualitative research method (observations, interviews) and a quantitative method – a questionnaire. We tried to do triangulation (Berg, 2004) in our research, i.e. we used three different research methods, "lines of sight". We validated the observations by interviews and questionnaire. The similarities in the results that we got using the different methods indicated that the results were reliable.

Classroom learning

The first step of the explanation was the classroom learning. First of all, to discover and explain the secrets of the game one needs to analyze the nature of the motion of the stick by applying the principle of "independence of motions". By taking into account the superposition of traversal and rotational motions, it's easy for students to imagine the qualitative picture for the trajectory of the stick. Moreover, within the secondary school or introductory university physics course it is possible to make accurate calculations. For the beginning it is reasonable to realize the simplest case, when the stick is supposed homogeneous and the throw is obtained only by hand rotation. The correspondent law of motion for every point of the stick is derived directly. The resulting trajectories form a set of cycloid curves, the famous ones which appear in different physics applications (Davydov V, 1989). The real throw is more complicated. Different players use different throws using not only the hand, but also the elbow, shoulder and torso rotation (this set of trajectories of different points of the stick is represented by figure 4).

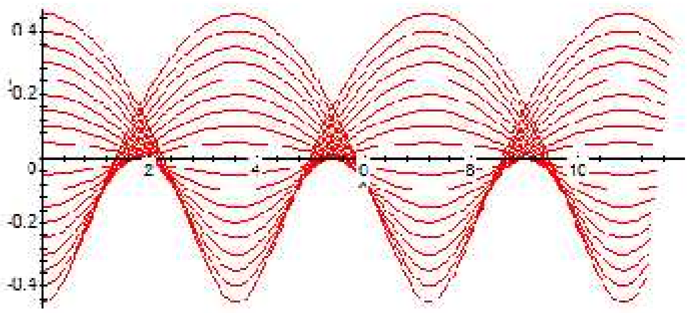

Figure 4

However, any real throw could be represented as a result of the rotation relatively single axis with effective length (the distance between the axis and the center of the stick) and transversal motion. In this case the law of motion takes the form:

$$\begin{cases} x(t) = (l + r)\omega t - r \sin \omega t \\ y(t) = -r \cos \omega t \end{cases}$$

Here r is the distance of the point from the center of the stick, l – the length of the stick, ω - angular velocity. The beginning of the coordinate frame corresponds to the position of the player. The resulting trajectories' form is a set of cycloid curves, which is rather difficult for the students to imagine. So it is reasonable to illustrate stick motion by visualization. The correspondent image sequence is presented on figure 5 for a homogeneous stick; x is the distance which the stick covers. This view of the trajectory is now a little bit easier for students.

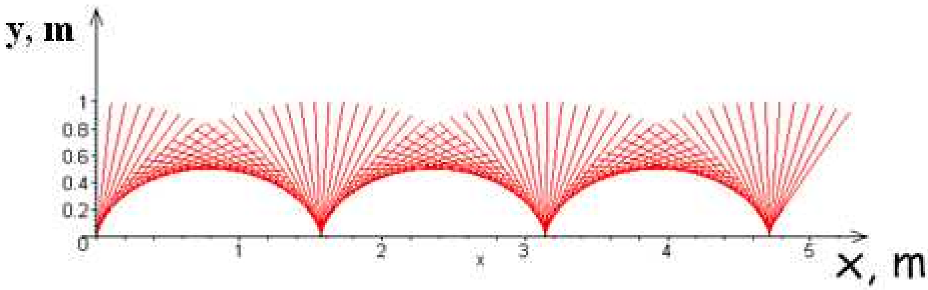

Figure 5

The typical value 1 m is chosen for the parameter l, but of course this value can vary in a wide interval depending on the mentioned parameters of the human body. At the end of the classroom learning a movie was shown to help the students. After that the students received a questionnaire which was "game-oriented". Unfortunately most students failed with their first answers.

Outdoors activities

The second step was the outdoor activities: the students played Priest actively, discussed the results, and tried to use different techniques of the throw. For example:

- Choosing the discrete distances at which the throw will be more successful and checking the dependence of these distances from the length of the stick and the physiological parameters. The trajectory of the stick does not depend on the angular velocity and the force of the throw. Frequently, children try to throw the stick harder or to twist it more rapidly. But soon they realized that it was a misconception. Due to their own experimenting they succeeded in proving that the trajectories have a periodical character with spacing depending on the parameter l. So the discrete set of lines for the most successful throws is individual for each player.
- Knocking off two tins located successively along the axis (Fig. 6).

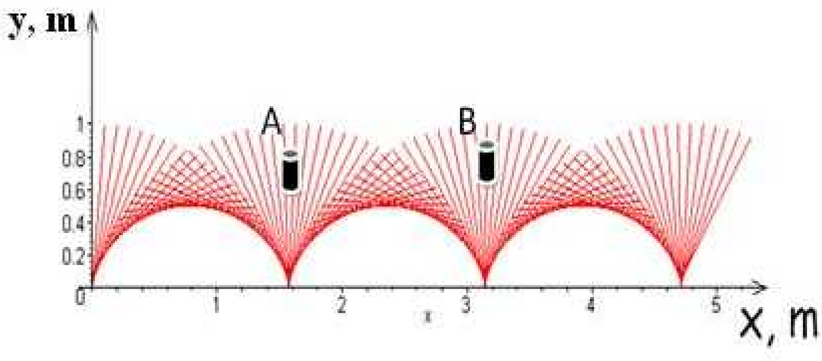

Figure 6

- Experimenting with the "gates" (Fig. 7). What is the minimal distance between these tins for which the stick will fly through the gate? Part of the students could try to calculate it; the other part could try to check it. The result of calculations for a special case of hand throw is: $h_{min} = 0{,}67R$. So the distance between the gate's doors could be about the third part of the stick. The result is even more amazing for the real throw, when shoulders and elbows are involved too. Here the value of is reduced to *l/6* or even less.

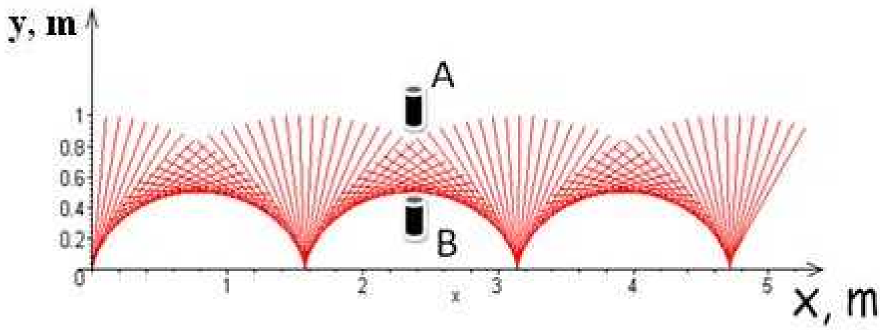

Figure 7

- Aiming at different places near the target in order to check the rule "aim little left for righthanders". The trajectory is asymmetrical. It means that the choice of the impact parameter is very essential. In particular, the player has more chances to succeed if his/her line of aim is slightly shifted to the *left* from the target for *right-handed* people and v.v.

Classroom discussion

The third step was a classroom discussion. During this lesson the students actively discussed their outdoor activities. It is worthwhile to stress that all students without any exceptions actively participated in the discussions. We regard this as the evidence of high communicative potential of the course design.

At the first step of the course designs – classroom learning, the students received a questionnaire which was "game-oriented". As was mentioned above, the qualitative results (at least the percentage of right answers) were rather low. The crucially improved version of the answers, inspired by students' outdoor experience, was one of the essential results of the mutual discussion. It proves that the course design appeared to be a good tool for students' recognition and of overcoming their original misconceptions.

It was also a pleasure and joy for us as the teachers to observe the process of generation of various creative thoughts during the discussion. The students actively shared the ideas on further “field experiments” and demonstrations. In particular they offered the possible new variants of the game, with variable parameters of the stick, with alternative geometry of the yard and displacement of tins.

Conclusions

- Students’ experience in and inspiration towards some well-known activity games are very important resources for Science course design.
- It is not so easy for the teacher to organize outdoors lesson. First of all, one must think about a place and equipment, about students’ safety; besides to take account of rainy – windy weather forecast and so on. Besides the main challenge for the teacher is to organize properly the students’ work, namely to turn “the just playing game” process into intriguing physical experiments, with reflections and planning. But these efforts will return with hundredfold.
- The tools for realizing this learning environment are extremely cheap or even free, including only the access to nature and very modest “set of equipment” – only a stick and several tins.
- The outdoors activities are powerful instruments for creating a productive learning environment.
- The construction of schemes based on everyday life experience of students remains an appealing challenge for teachers.

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PREDICTORS OF CHEMISTRY SELF-EFFICACY AMONG COLLEGE STUDENTS

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Abstract: Self-efficacy beliefs determine students' choices in performing science-related tasks, their efforts to do them, and their persistence and perseverance when faced with difficulties. Because of the task and domain specifity of self-efficacy, this construct should be interpreted within a specific domain. There is a gap in the literature which examines students' self-efficacy beliefs in specific areas of science such as chemistry. The purpose of this study was to investigate the contribution of academic achievement, the number of chemistry courses taken, involvement in a chemistry project, expected grade, and gender to college students' chemistry self-efficacy beliefs. Data were collected by administering the College Chemistry Self-Efficacy Scale (CCSS) developed by Uzuntiryaki and Capa Aydin to 488 college students. The CCSS consisted of 21 items in three dimensions: self-efficacy for cognitive skills (SCS), self-efficacy for psychomotor skills (SPS), and self-efficacy for everyday applications (SEA). The results of the Multiple Linear Regression analyses indicated that the number of chemistry courses taken, involvement in a chemistry project, and expected grade were significant predictors for SCS; the number of chemistry courses taken was significant predictor for SPS, and the number of chemistry courses taken, involvement in a chemistry project, and expected grade were significant predictors for SEA.

Keywords: self-efficacy, multiple linear regression, chemistry, college students, science education

INTRODUCTION

Self-efficacy is defined as "beliefs in one's capabilities to organize and execute courses of action required to produce given attainments" according to social cognitive theory, proposed by Bandura (Bandura, 1997, p. 3). Bandura (1986, 1997) posited that self-efficacy beliefs developed as a result evaluation of four sources: Mastery experiences, vicarious experiences, verbal and social persuasion, and physiological state. Research studies conducted in the past decades explored the importance of self-efficacy beliefs in education by showing the relationship between self-efficacy and academic achievement, engagement, self-regulation, and career choice (Britner, 2008; Pajares, Britner & Valiante, 2000). In addition, self-efficacy beliefs determine students' choices in performing science-related tasks, their efforts to do them, and their persistence and perseverance when faced with difficulties (Bandura, 1986). In line with the Bandura's argument related to association between self-efficacy and students' choices in performing science-related tasks, Dalgety and Coll (2006) reported that first-year chemistry students with high self-efficacy beliefs intended to study chemistry at second-year level. Related literature includes contradictory research findings in terms of gender difference. For instance, female students reported stronger self-efficacy in science classes than males (Britner, 2008), while females were less efficacious in studies conducted by Anderman and Young (1994) and Britner (2008). On the other hand, Capa Aydin and Uzuntiryaki (2007) indicated that there was no significant difference by gender. Because of the task and domain specifity of self-efficacy, this construct should be interpreted within a specific domain (e.g., science, chemistry, physics, etc.). In the literature, there are many studies focused on students' science self-efficacy beliefs in domain general areas. However, there is a gap in the literature which examines students' self-efficacy beliefs in specific areas of science such as chemistry. The present study aimed at investigating the contribution of academic achievement, the number of chemistry courses taken, involvement in a chemistry project, expected grade, and gender to college students' chemistry self-efficacy beliefs. It is hoped that identifying these factors will be helpful in designing instructional strategies that promote self-efficacy.

METHODS

Sample

The sample consisted of 488 students in a mid-western college in USA. Of 488 students, 269 of them were female and 219 of them were male. Their ages ranged from 17 to 48 with a mean value of 20.2 and a median of 19.

Instrument

In this study, data were collected using the College Chemistry Self-Efficacy Scale (CCSS) developed by Uzuntiryaki and Capa Aydin (2009). The scale consisted of 21 items in three dimensions: self-efficacy for cognitive skills (SCS), self-efficacy for psychomotor skills (SPS), and self-efficacy for everyday applications (SEA). Findings of confirmatory factor analysis provided evidence for the three-factor structure of the CCSS for USA sample with relatively satisfactory fit indices (CFI = 0.97; NNFI = 0.97; RMSEA = 0.10). Analysis of internal consistency reliabilities yielded Cronbach alpha coefficients of 0.87 for self-efficacy for cognitive skills, 0.92 for self-efficacy for psychomotor skills, and 0.86 for self-efficacy for everyday applications, indicating satisfactory reliability. In addition, a demographic form was included asking participants to report their gender, age, GPA, the number of chemistry courses taken, whether or not they participated in a chemistry project, and expected grade (A, B, C, etc.).

Data analysis

In order to investigate the role of academic achievement, the number of chemistry courses taken, involvement in a chemistry project, expected grade, and gender in predicting college students' chemistry self-efficacy beliefs, three separate Multiple Linear Regression analyses were conducted. The outcome variables were self-efficacy for cognitive skills, self-efficacy for psychomotor skills, and self-efficacy for everyday applications. GPA, gender, number of chemistry courses taken, involvement in a chemistry project, and expected grade were predictor variables. Expected grade variable was dummy coded taking grade A as a reference level. Dummy 1 refers to pairwise comparison between grade A and grade B. Dummy 2 refers to pairwise comparison between grade A and grade C.

RESULTS

Multiple regression analysis for SCS

Results indicated that the model explained 18.7% of the variation in SCS ($F(6, 348) = 13.30$, $p<0.05$). The number of chemistry courses taken ($\beta = 0.155$), involvement in a chemistry project ($\beta = 0.113$), and expected grade ($\beta = 0.328$ for dummy 1, $\beta = 0.366$ for dummy 2) were significant predictors of SCS. Table 1 presents unstandardized coefficients (B values and standard error) and standardized coefficients (β) for the predictors.

Table 1. Unstandardized and standardized coefficients for the predictors for SCS

	B	Std. Error	β	Sig.
(Constant)	7,354	,681		,000
gender	,086	,118	,037	,466
chemcour	,093	,030	,155	,002*
gpa	-,065	,141	-,026	,648
chemproj	-,431	,185	-,113	,020*
DUMMY2	-1,100	,193	-,366	,000*
DUMMY1	-,764	,137	-,328	,000*

*p<0.05

Multiple regression analysis for SPS

Results showed that 3.7% of the variation in SPS was explained by the model ($F(6, 348) = 2.22$, $p<0.05$). The number of chemistry courses taken ($\beta = 0.128$), was the only significant predictor of SPS (see Table 2).

Table 2. Unstandardized and standardized coefficients for the predictors for SPS

	B	Std. Error	β	Sig.
(Constant)	8,178	,890		,000
gender	-,036	,154	-,013	,813
chemcour	,092	,039	,128	,019*
gpa	-,222	,185	-,075	,231
chemproj	-,404	,241	-,088	,095
DUMMY2	-,350	,252	-,097	,165
DUMMY1	-,272	,179	-,097	,129

*p<0.05

Multiple regression analysis for SEA

The model accounted for 10.2% of the variation in SEA ($F(6, 348) = 6.62$, $p<0.05$). The number of chemistry courses taken ($\beta = 0.185$), involvement in a chemistry project ($\beta = 0.134$), and expected grade ($\beta = 0.198$ for dummy1, $\beta = 0.193$ for dummy 2) were significant predictors of SEA (see Table 3).

Table 3. Unstandardized and standardized coefficients for the predictors for SEA

	B	Std. Error	β	Sig.
(Constant)	7,273	,836		,000
gender	,049	,144	,018	,733
chemcour	,130	,037	,185	,000*

gpa	-,127	,173	-,044	,465
chemproj	-,593	,226	-,134	,009*
DUMMY2	-,676	,236	-,193	,004*
DUMMY1	-,538	,168	-,198	,002*

*p<0.05

CONCLUSIONS AND IMPLICATIONS

This study investigated the role of the academic achievement, number of chemistry courses taken, involvement in a chemistry project, expected grade, and gender in predicting college students' chemistry self-efficacy beliefs. Results indicated that the number of chemistry courses taken, involvement in a chemistry project, and expected grade were significant predictors for SCS; the number of chemistry courses taken was significant predictor for SPS, and the number of chemistry courses taken, involvement in a chemistry project, and expected grade were significant predictors for SEA. The number of chemistry courses taken was the only variable which predicted chemistry self-efficacy in all three dimensions (SCS, SPS, and SEA). In addition, involvement in a chemistry project significantly predicted the SCS and SEA. These results were in line with Bandura's claim which states that the more experience with a task students have, the higher self-efficacy they have (Bandura, 1986; Bandura, 1997). Britner (2008), Britner and Pajares (2006) and Lent, Lopez, and Bieschke (1993) also found similar results. On the other hand, involvement in a chemistry project was not a significant variable for SPS. This study did not explore the type of chemistry projects in which students engaged; therefore, it is not possible to identify whether the chemistry projects addressed to all skills (cognitive and psychomotor) in chemistry. In terms of expected grade, there was a significant difference in favor of high grades, A. As students expect higher grades in chemistry courses, they reported higher efficacy. It is crucial for instructors to be aware of the self-efficacy sources and the contribution of variables such as academic achievement and gender to students' self-efficacy beliefs to design their courses effectively. This study was limited in terms of ways of collecting data. All of the variables were self-report measures, which limits the interpretability of results. Further research utilizing qualitative method is warranted to elaborate students' experiences and their self-efficacy beliefs.

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CHARACTERISTICS OF REAL LIFE CONTEXTS AND THEIR INFLUENCE ON STUDENT INTEREST IN LEARNING CHEMISTRY

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Abstract: Over the last thirty years, an increasing number of approaches for the development and implementation of context-based curricula has emerged all over the world. Their aim is to raise student interest in chemistry by pointing out the relevance chemistry content and its application outside school. Although different studies have shown a positive effect on student interest and motivation if real life contexts are integrated, a more differentiated look at results shows that they vary significantly depending on the chosen context.
Based on this background, the presented study analyzes the influence of context characteristics on student interest in learning chemistry. When these characteristics have been elaborated, defined and substantiated by a rating and a student inquiry, student interest in contexts with specific characteristics will be investigated. The results of the rating can be used as a basis for the construction of a questionnaire to validate the constructed contexts with the help of a student inquiry. Contexts with a clear attribution of the respective characteristic could be selected for the interest investigation.

Keywords: student interest, context-based learning, context characteristics

PURPOSES

As interest and motivation are central objects of educational research, their role in successful learning processes has already been well-investigated (Krapp, 2002). In their meta-analysis, Schiefele, Krapp and Winteler (1992) reported a correlation of r = .30 between interest and learning achievement. Against this background, the results of large-scale interest studies in natural sciences, especially in physics and chemistry, show an alarming status quo. A national cross-section analysis, conducted by the IPN in Germany, for example, make obvious that physics and chemistry are the most uninteresting subjects, especially for girls (Hoffmann, Häußle, Lehrke, 1998). Over-loaded curricula with an inadequate emphasis and an acquisition of isolated facts without relevance and transfer to everyday life lead to a lack of interest (Gilbert, 2006).
Since the beginning of the 1980s, Science-Technology-Society, context-based or the more recent socio-scientific issues-based approaches have developed new curricula and learning materials by embedding scientific contents in out-of-school contexts. The basic idea is to point out the relevance and applicability of these contents in order to raise student interest and increase achievement.
However, a systematic and category-based selection of the chosen contexts cannot be found in any of the approaches. How and why a context is chosen does not become clear.

Although a large number of studies could verify a positive effect on student interest by using contexts in scientific education (e.g. Ramsden, 1997), a closer look at the results of large-scale interest studies, like the international SAS- or ROSE-study, reveal that interest varies significantly depending on the chosen context. Figure 1 illustrates this issue with the help of exemplary results from the SAS-study.

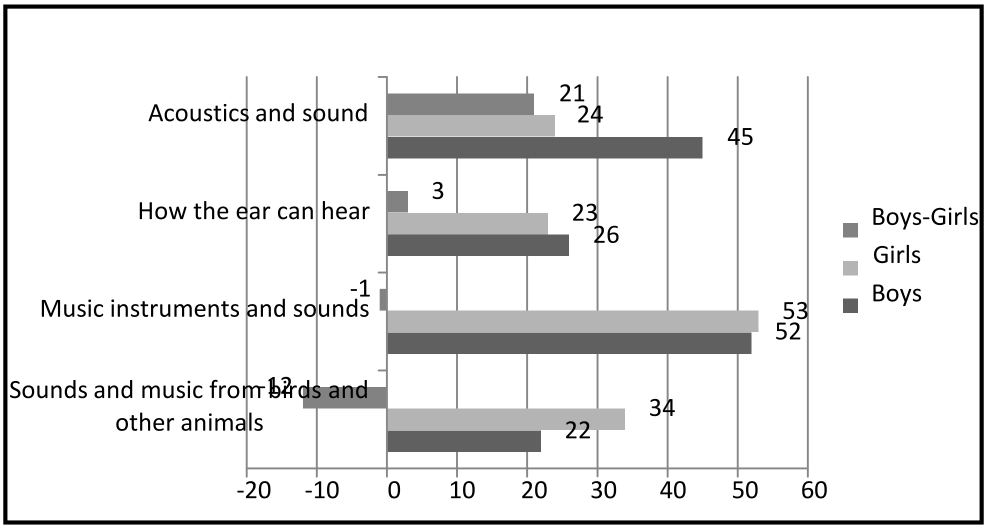

Fig. 1: Interest in different contexts in the physical content *acoustics* (Sjøberg, 2000)

Consequently, the question arises, which specific characteristics make a context interesting for students. The presented study deals with this central question.

THEORETICAL BACKGROUND

Interest and Context-Based Learning

Based on Krapp (1992), interest emerges from a specific interaction between a person and an object, an activity or a field of knowledge. It is composed by a value-related valence, specifying the quality of personal significance, and a feeling-related valence, which is determined by positive experiences while being engaged in an activity. Interest can be "[…] generated primarily by certain conditions and/or concrete objects (e.g. texts, film) in the environment" (Krapp, Hidi, Renninger, 1992, p. 8). Hence, it is caused by external factors and is limited to a specific situation (*situational interest*). *Individual* or *personal interest* is determined by the overlasting dispositional structure of the person. The engagement in the area of individual interest does not need an external stimulation and does not depend on a specific situation.

In a concrete learning situation, the teacher cannot control the students' incoming personal interest but can rather influence situational interest by changing the interestingness of the object. This can be achieved by the chemical content itself, by the chosen activities, or by learning materials. An additional possibility is an adequate embedding of the content in an interesting context. Bennett and others (2005) have evaluated the effectiveness of this approach by comparing teachers' views. Teachers, following the context-based approach *Salters Advanced Chemistry* have reported continuing and increased interest and motivation in their courses as compared to teachers following traditional chemistry education. Additionally, Ramsden (1997) compared statements of students about their experiences during their chemistry courses. His results reveal that students who have attended a context-based course, are especially interested in the relation to everyday life. Fechner (2009) found similar results.

She conducted an intervention about five lessons to compare the effects of context-oriented learning materials with traditional materials on students' interest and learning achievement. Within her study, an increased situational interest was induced by real life contexts. Additionally, it mediated an increased learning achievement. As Fechner has used different contexts for each lesson, her results also show significant differences in students' interest and achievement depending on the context.

Context Characteristics

Taking a look at the literature of different context project groups all over the world, various characteristics for the specification of contexts can be found. Figure 2 gives an overview of the central context characteristics. As *relation to everyday life, topicality* and *uniqueness* were extracted for further analysis, these characteristics are depicted in the foreground.

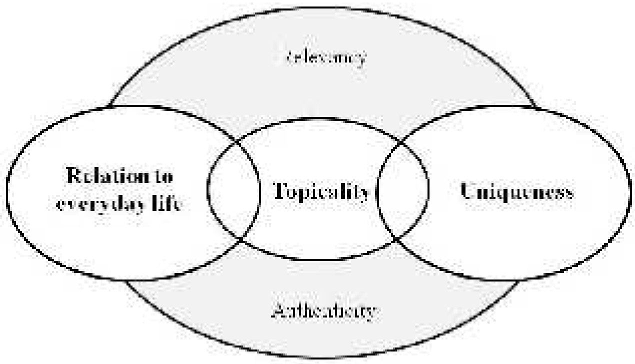

Fig. 2: Context characteristics

To achieve *relation to everyday life* in learning materials, objects of the immediate environment of the students, characterized by familiarity and normalcy, can be used as a context. The opposite alternative is using uncommon objects, which are beyond the students' immediate environment, so that they are not familiar with them. Thereby, the characteristic of *uniqueness* is fulfilled. Moreover, normal or unique objects can be topical, as they are actually published by the media or determined by the present season or an approaching holiday. This issue is represented by the characteristic of *topicality*.

By considering these categories, the characteristics of *relevancy* (e.g. Kasanda et al., 2005) and *authenticity* (e.g. Parchmann, Ralle & Di Fuccia, 2008) should be guaranteed as well. Considering a simplified definition of *relevancy* in the philosophy of language, it is determined by a specific interaction between the student and its environment. With respect to this, the relevant object cannot be seen as an individual entity but is given significance by its environment (Sperber & Wilson, 2006). Within the PISA-study personal, social and global relevance are distinguished (Schleicher, 2001). According to Krapp's concept of interest, personal relevance represents the value-related valence of interest, which leads to situational or individual interest. Hence, personal relevance can be seen as an individual personality trait and can hardly be realized as a context characteristic for learning materials. Consequently, only social and global relevance are considered as context characteristics for the presented study.

The characteristic of *authenticity*, another central characteristic in the literature, is the perceived genuineness of the object. Furthermore, authentic contexts are determined by a certain extent of *complexity* and, hence, provide different alternatives of dealing with the context. Finally, it is important to adapt a context to the students' age, to the curriculum and other general conditions of school (Bayrhuber et al., 2007), which has been summarized by the category *adaptivity.* For the presented study the two categories of *complexity* and *adaptivity* are standardized by a manual and will not be varied systematically.

METHODS

The presented context characteristics are basic for the analysis of the research aim. Therefore, a detailed operationalization of the characteristics is necessary. Hence, the study is divided into two project phases: (1) the operationalization of the characteristics and (2) the analysis of their influence on student interest. The emphasis of the following paragraph is placed on the first project phase, as this represents the current status of work.

Project Phase 1

Initially, it was necessary to determine the characteristics for the description and categorization of contexts, as specified in the context literature. The resulting categories are introduced above. As a manual for context construction provides information on the right amount of *adaptation* and standardizes the level of *complexity* of each context used in this study, these characteristics have not been included in Figure 2.

The operationalization of the main categories *relation to everyday life, topicality* and *uniqueness* has been realized by formulating paraphrasing statements and adjectives as keywords. Two methods were intended to validate them: a rating with colleagues from educational research and student teachers, and a student inquiry.

For the first rating, 35 paraphrasing statements (e.g. *'This is a common object for me.')* were formulated. The inquiry was conducted with 72 participants in November 2010. During the inquiry, the raters had to decide which characteristic is paraphrased by the respective sentence. An additional approach, the semantic differential, was used for the validation of the keywords. As *relation to everyday life* and *uniqueness* are two opposite categories, their adjectives were subsumed in one scale for the semantic differential.

For the student inquiry, 60 exemplary contexts were constructed with the help of the operationalized characteristics. The chosen contexts are all based on organic chemistry content.

	Topicality	
	Yes	*No*
Relation to everyday life	15 context	15 context
Uniqueness	15 context	15 context

Fig. 3: Design for the context construction

The paraphrasing statements were combined in a questionnaire and the contexts were distributed to different assessment forms with the help of a multi-matrix sampling. Each assessment form includes six different contexts. 592 students of the ninth grade of upper secondary schools (German *Gymnasium*) in North Rhine-Westphalia have filled in one questionnaire, consisting of the paraphrasing statements, for each exemplary context. Contexts with a clear attribution of the respective characteristic could be selected for the second phase of the project.

Project Phase 2

In the second project phase, the interestingness of specific contexts will be analyzed. Therefore, a second student inquiry will be conducted. 24 selected contexts (6 contexts for each cell) from the first project phase will be distributed to different assessment forms again. A questionnaire about the interestingness of each context will be administered to 600 ninth-grade students of upper secondary schools.

RESULTS AND DISCUSSION

Data from the first validation was analyzed with the help of the statistics software SPSS®. The data analysis of the paraphrasing statements has shown an inter-rater agreement of κ=.918. Data on the relative frequency of selection was used to determine the final statements for each context category, which were combined in a questionnaire for the first student inquiry. Five statements were selected for each characteristic. For the characteristics *relation to everyday life* and *topicality* phrases with a relative frequency of 95 % and more were selected, for the characteristic *uniqueness* five phrases with a relative frequency of 91.5 % and more could be chosen.

In order to select keywords for the semantic differential, pairs of antonyms with a relative frequency of more than 80% have been chosen. Additionally, a univariate analysis of variance has been calculated for each pair to see, whether the pair was able to differentiate between the characteristics in a significant way. Based on this, five pairs of adjectives per scale could be selected for the student inquiry. The internal consistency estimates of the composed scales are α = .83 for *relation to everyday life/uniqueness* and α = .80 for *topicality.*

A preliminary data analysis of the first student inquiry was conducted with the help of the Rasch-model. Therefore, the software Winsteps® was used. As the items for *relation to everyday life* and *uniqueness* can be seen as two opposite poles of one scale, they could be combined for the following analysis. The two resulting scales (one scale for *relation to everyday life/uniqueness* and one scale for *topicality*) were entered into the analysis as separate dimensions.
In order to analyze the data of the paraphrasing statements a rating scale model was calculated. An analysis of the category structure showed that the chosen 4-point Likert-scale fits the Rasch-model (Linacre, 2011). Table 1 shows some general statistical values for the three dimensions:

Table 1: Statistical values for the dimensions of the paraphrasing statements

		Relation to everyday life/ Uniqueness	Topicality
	Sample Size	592	592
Item:	Reliability	.95	.95
	Separation	4.39	4.32
Person:	Reliability	.87	.84
	Separation	2.56	2.28
	Raw variance explained by measures	54,5 %	43,0 %

For the analysis of the semantic differential a partial credit model was used. During the analysis of the category structure it became obvious that the chosen 7-point Likert-scale was not able to fit the Rasch-model. Hence, it was necessary to combine some of the steps. A reanalysis showed that a 3-point Likert scale for *relation to everyday life/ uniqueness* and a 6-point Likert scale for *topicality* were able to fit the Rasch-model. Table 2 gives an overview on the general statistical values for the semantic differential:

Table 2: Statistical values for the dimensions of the semantic differential

		Relation to everyday life/ Uniqueness	Topicality
	Sample Size	592	592
Item:	Reliability	.94	.94
	Separation	4.05	3.89
Person:	Reliability	.78	.86
	Separation	1.90	2.45
	Raw variance explained by measures	45,1 %	37,5 %

The main aim of the data analysis was to verify the supposed attribution of the characteristics and to select contexts with a clear characteristic attribution for the following inquiry. This aim was realized with the help of an item map for each scale. One can assume that contexts with a clear attribution of the according characteristic are located at the bottom of the item map, because it was easier for students to relate the characteristics to these contexts (Bond & Fox, 2001). Based on this assumption, six contexts for each cell in Figure 3 could be selected for the second student inquiry. As *topicality* of contexts changes in a quite short period of time, it was necessary to construct ten new contexts for the characteristic *topicality.* In order to control the characteristic attribution for these new contexts, a shorten version of the questionnaire consisting of the paraphrasing statements will be added to the interest questionnaire for the second student inquiry.

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EVALUATION OF EDUCATIONAL DESIGN METHODOLOGY UTILIZING CONCEPT MAPPING

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Abstract: One goal of educational design research is to provide guidelines for the design process. This paper reports on our on-going work on the development of such guidelines by evaluating the design procedure of a pre-service chemistry teacher education course on models and visualization. In the design of the course, the concept maps were utilized as interactive road maps for coordination and documentation of the co-operative development of the design solution. Description of the roles and collaboration between the developers in the design process are presented as a design narrative based on the analysis of semi-structure interviews of three course developers. The evaluated design process had six phases: (i) establishing goals for the design procedure, (ii) evaluation of the initial design solutions, (iii) collaborative construction of the design solution, (iv) implementation of the design solution, (v) evaluation of the design solution, and (vi) evaluation of the design procedure. During the course, the concept map created during the co-operative construction of the design solution was used as a summary of the objectives of the course, management tool, and description of the design process. Based on the results, the presented design methodology is a promising way of utilizing concept maps in coordinating the co-operation of multiple designers in educational design-based research.

Keywords: design research, design based research, concept maps

BACKGROUND AND RATIONALE

For the past 20 years, several papers have discussed educational design research (e.g. Bell, Hoadley & Linn, 2004, Brown, 1992; Cobb, 2001; Dede, 2004; Edelson, 2002; Juuti & Lavonen, 2006). In design research the research-based development is carried out in a real-world situation systematically, flexibly and iteratively through continuing evaluation and expertise of various interest groups (Wang & Hannafin, 2004).

Daniel Edelson (2002) describes three elements of design research: (i) the *problem analysis* characterizes the goals and opportunities of the design as well as the challenges and constraints it has, (ii) the *design solution* describes the resulting design, and (iii) the *design procedure* specifies the processes and people that are involved in the development of the design. According to Edelson, design research produces three types of theories corresponding with these elements: (i) *domain theories* are generalizations of some portion of the problem analysis, (ii) *design frameworks* describe the characteristics of a successful design solution, and (iii) *design methodologies* provide guidelines for the design process.

One possible way to organize, to visualize, and to document a design process is to use concept maps. Concept maps are graphical teaching, learning, evaluation, and presentation tools that were devised as a device of Ausubel´s (1968) theory of meaningful learning. Concept mapping helps organize concepts related to the topic, shows interrelationships among concepts, and illustrates how the concept structure of the topic is constructed (Novak 1998).

As design research has tended to focus on descriptions of design frameworks and domain theories rather than on developing design methodologies, there is a need for new approaches in design procedures. This paper reports on our on-going work on the development of an educational design methodology utilizing concept mapping.

METHOD

In this study, the design procedure of a pre-service chemistry teacher education course on molecular modelling is evaluated by providing a description of the process for pedagogic course design as well as the roles and collaboration of the developers (see Edelson, 2002). A researcher, who did not take part in the design and development of the course, interviewed the three teachers responsible for the course. In semi-structured interviews, these co-developers were asked to describe the design procedure and their role in it, and how they utilized concept mapping in the design and implementation of the course.

Design narrative is a comprehensive description of the whole design process. It explains design conditions, decisions, goals, challenges, and results and is usually created by the developers (Bell et al., 2004; Juuti & Lavonen, 2006). In addition to interviews, the results presented in this study are based on the published initial design narrative written by the developers (Pernaa, Aksela & Västinsalo, 2010).

By qualitative content analysis of the interviews and initial design narrative, a new design narrative was created, focusing on the design methodology, the roles of the developers and the use of concept mapping in the design process.

The questions driving this study were:

(1) How the co-developers collaborated during the design process?

(2) How the roles the three co-developers assumed contributed to the design process?

(3) What purposes concept mapping served in the design process?

Role of Researchers

Second and third authors worked as co-developers and teachers of the course. To objectively analyse the roles developers assumed in the design process, a decision was made that someone who had not worked on the course should make the interviews and analysis. This was the case, as before the interviews the first author had no previous affiliation with the course. However, as the first author is working in the same teacher education unit, the authors recognized there is a possibility for bias, as even the first author has vested interest in the program.

Although the evaluation was done solely by the first author, two co-developers (second and third author) contributed to writing the final design narrative presented here. To ensure the credibility of the results (see Lincoln & Cuba, 1985), a member check was carried out by providing also the third co-developer with the results and conclusions for comment.

RESULTS

Collaboration during the design process

Based on the interviews and initial design narrative (Pernaa et al., 2010) the design process had six phases: (i) *establishing goals for the design procedure*, (ii) *evaluation of the initial design solutions*, (iii) *collaborative construction of the design solution*, (iv) *implementation of the design solution*, (v) *evaluation of the design solution*, and (vi) *evaluation of the design procedure*.

The first phase was not reported in the initial design narrative and the developers did not explicitly discuss the goals of the design procedure. Every developer saw the need for improving the design solution, but at least one of the developers was not aware of the goal of developing the design process as well as the design solution. This caused some problems during the later phases. For example the initial problem analysis and the changes made to the design solution during the implementation were not adequately documented, as all the developers were not aware on how the documentation would be used in the evaluation of the design.

To evaluate the initial design solutions, the developers got acquainted with the feedback and materials from the previous implementations of the course. Based on this problem analysis describing the goals, needs, and opportunities presented by the design context, the developers worked collaboratively to produce a description of the design solution. The concept map was used as a tool for documentation and visualization in constructing a consensus design solution. Concept map created by one of the developers was used as a root model, where all changes, solutions and challenges were documented. The process is visualized in figure 1.

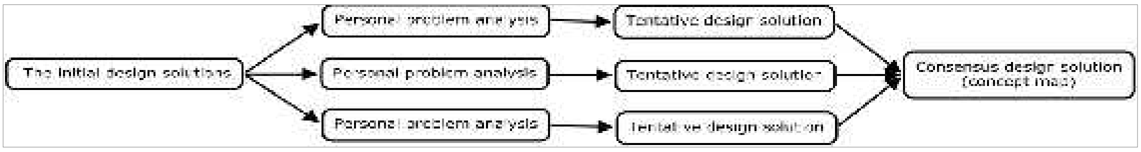

Figure 1. Evaluation of the initial design solutions and the collaborative construction of the design solution.

Roles of the co-developers and concept mapping in the design process

The different roles of the three developers were apparent in the construction of the design solution. The developers included a professor responsible for the course, a PhD student working as an instructor on the course for the second time, and a recently graduated teacher with master’s degree in chemistry education.

The recently graduated teacher had been a student on the course previous time the course was held. During the design and implementation of the course, she reflected mainly on her own experiences as a student. Her contributions were mostly concentrated on improving the practicalities of instruction (*e.g.* software tutorials and modelling exercises). She saw the concept map as a tool for coordinating teaching: From the concept map presenting the consensus design solution (see figure 1) she could see what were the objectives of the course and how the teaching responsibilities were divided. Although she participated in analysis of the research data and writing the article reporting the initial design narrative (Pernaa et al. 2010), she did not feel she contributed much to the research part of the design research process. As a newcomer to the development team, she had a hard time evaluating the contributions of the other teachers developers.

The second developer was a PhD student working for the second time as the teacher on the course. He was writing his PhD thesis on the use of design research in chemistry teacher education. As the main author of the initial design narrative (Pernaa et al. 2010), he concentrated on documenting the design process as well as developing the technical aspects of the course. Having the responsibility of coordinating the course and the design research process, he seemed to be very aware of the contributions of the other co-teachers and developers. Although actively involved in the design process, he felt that he should rely on the expertise of the professor on some issues, such as on deciding the overall goals of the course. In his opinion the teaching responsibilities during the course were quite evenly distributed: The professor gave lectures about the more theoretical aspects of the course, while the other teachers were responsible for supervising and evaluating the assignments. With his attention focused on the design research process, he saw the concept map presenting the consensus design solution mainly as the visualization of the design process. As the design research project was part of his PhD thesis, he had the main responsibility in the research project.

The third developer was professor and head of the unit. She had been involved in every implementation of the course since 2003, when the course was taught for the first time. Her contributions to teaching were mostly directed to develop the goals of the course and the division of labour among the teachers. She saw concept map presenting the consensus design solution as an overview of the course design. Her focus on the development of the course was on the students that the pre-service teachers would one day be teaching. As the supervisor of the PhD students she also participated actively in the research process. Although she wanted to support the autonomy of her PhD students and co-developers, and to encourage them to follow their own interests, she also felt that she is ultimately responsible for the quality of the teaching and research. On day-to-day issues of teaching she trusted the judgement of the other teachers and considered their contribution crucial to the final design of the course. For example, the professor noted that the perspective of someone, who had recently been a student on the course, was direly needed to ensure the relevancy of the course in the eyes of the students.

CONCLUSIONS AND IMPLICATIONS

The developers had distinctly different roles in the construction of the design solution. The less experienced teacher educators focused on the practicalities of teaching and research, and the more experienced professor of teacher education focused on the students as future teachers and supporting the other teacher educators in their teaching and research.

Also other researchers have noted the shift of focus from practicalities of teaching to a more student-centred view. Peter Kugel (1993) describes the professional development of university teacher moving from focusing on their own role as teachers, through focusing on understanding of the subject matter they teach and students' ability to absorb what they have been taught, to finally focusing on helping students learn to use what they have been taught and developing independence and autonomy. The roles designers took in the construction of the design solution seems to be related to their experience as teacher educators much in the way described by Kugel. This does not mean, that inexperienced teacher educators are less valuable for the educational design process: Even though the focus seemed to develop through experience, there was a special need for fresh perspectives.

In the implementation phase, the concept map worked as a "road map" or curriculum for the course. The design solution evolved over the course through analysis and formative evaluation: all things described by the initial concept map were not implemented and some additional elements were added on the course curriculum. The concept map had many uses during the implementation. Developers saw it, among other things, as a description of the objectives of the course, management tool, and description of the design process.

Based on the evaluation of the design procedure, concept map is a useful and versatile tool in educational design research. Edelson (2002) points out that constructing a design solution is a process of creating and evaluating alternative solutions from multiple perspectives. Concept maps can be used to decompose the "complex design problem into manageable components" (p. 109). Concept maps can also be utilized during the implementation as interactive road maps documenting the development of the design solution.

The design methodology presented here is a promising way of utilizing concept maps in coordinating the co-operation of multiple designers in a design research process. The use of concept mapping in the design methodology could be developed even further. To ensure that everyone understands the design process and the importance of adequate documentation, there was a need for conversation about the goals of the design procedure. In such a discussion, concept maps could be used in visualizing and documenting the decisions made in establishing the goals for the design procedure.

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THE POTENTIAL OF AN OUT-OF-SCHOOL LABORATORY TO IMPROVE THE IMAGE OF PHYSICS AND CHEMISTRY

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Abstract: Over the last years, new approaches have been proposed to increase the quality of science education. Among them, laboratories that promote inquiry based learning by focusing on scientific methods play an important role. The labs are based on the idea that bringing students into contact with authentic research and development may improve the image of science. A negative perception of school science can be considered as one of the major causes for the decreasing percentage of young people majoring in science and technology. Empirical findings show an implicit association of the 'hard' sciences, especially physics, with difficulty, masculinity and heteronomy. Until now, very few investigations have explored ways how the image of physics of adolescent students can be improved.

The aim of this research is to determine the effects of hands-on, practical, cooperative laboratory-based inquiry activities on students' views of science and technology. For this purpose, the development of key affective variables such as self concept, career orientation and the image of physics and chemistry are examined in the context of Baylab plastics, a recently founded laboratory in industry. In this lab students are given the opportunity to cooperate in groups to design and produce a plastic product within one day using state of the art technology for production modern testing equipment. The lab approach promotes many inquiry-based and learner led activities which foster a creative access to material science. The results show that the lab improves the students' self concept as well as their image of science, especially in the domain of physics.

Keywords: image of science, inquiry-based learning, out-of-school laboratory, role of authentic science, technology laboratory

BACKGROUND, FRAMEWORK AND PURPOSE

In many industrialized countries serious concerns have been raised over the status of science education and the decreasing interest of young people for science subjects. In order to react adequately to the economical, social and ecological challenges in an ever-changing world and to keep up the pace of innovation the increasing uptake of science and technology related studies and professions is considered necessary by the majority of industrialized countries.

The current practice of science education is under challenge. For instance, a high portion of scientifically competent students in Germany have little to no interest in science subjects (PISA Konsortium, 2008). Especially, physics has a negative image, associated with attributes such as *abstract*, *dry, demanding* and *ambitious* (Euler, 2001) and with *difficult*, *masculine* and *heteronomous* (Kessels et al., 2006). There are many reasons for the declining interest during adolescence, for example missing reference to everyday life and missing opportunities to engage in meaningful learning (Euler, 2009).

Kessels et al. (2006) define the image as common assumptions about the characteristics and contents of a subject. It is considered as a possible factor for the negative development of interest. Often students think lessons in physics offer fewer opportunities to create innovative ideas (Kessels et al., 2006). They see physics and chemistry as a collection of facts and do not see that discussing, debating and negotiating the meaning of concepts are important factors in the development of scientific knowledge (Driver et al., 1995). A negative image in connection with specific learning difficulties can be considered the major causes for the decreasing percentage of young people choosing science and technology for profession.

In order to promote students' interest and motivation for natural sciences and to increase the level of scientific literacy the European Commission recommends a more student oriented approach to education in the field of mathematics and science. In contrast to the prevailing traditional deductive teaching style, inductive methods like inquiry and experienced based learning are considered more appealing and cognitively activating (Gago, 2004). Inquiry-based learning is regarded as a key factor for improving students' interest and achievement in science (Rocard et al., 2007).

Innovative approaches to inquiry- and discovery-based learning can be implemented more easily in learning environments like out-of-school laboratories because they do not underlie curricular and syllabus restrictions of the conventional school system. Students can be involved in inspiring and activating learning contexts that are relevant for everyday life or touch upon the interaction of science, technology, economy, and social processes. Such learning laboratories that focus on authentic scientific or technological processes prove successful in increasing interest (Euler, 2009). Their program emphasizes on what students know about science and how they experience science and technology in their everyday life. By contrast, teachers seem to focus more on science concepts (Rennie, 2007). Science education in school and out-of-school-settings can be viewed as “two components of one inclusive education system” (Bybee, 2001).

The present project focuses on the question whether an out-of-school-laboratory has the potential to improve students' attitude towards science, especially the image of physics and chemistry. The empirical study is carried out in Baylab plastics, a school lab run by Bayer MaterialSience. This company is part of the Bayer Corporation and produces high performance plastics and polymers. Baylab plastics pursues an innovative and demanding approach to experience based learning in an authentic industry setting. In order to experience a working day in industry students are presented the challenge to develop, create and complete a modern lifestyle plastic product such as a case of a computer mouse, the frame of sports glasses or a plastic spoon. For this purpose they engage in the various facets of the actual production process from research to design and completion, working together in five different teams: Design, Research, Technology, Finance and Communication. The selection of the teams is guided by the students' interest.

In order to solve the challenging task, students have to deploy different skills in design, management, research and technology fields. For example, the research team has to test if the plastic granulate is dry enough for the production process or to check the quality of the product (e.g. examine if the plastic spoon is dishwasher safe). The technology team has to learn about the function of the extruding machine and run the production process. All groups have to become active, ask questions, identify problems and find solutions. Reflection and communication are indispensable for the group work and for the interaction between the groups. Thus, the program aims at experiencing creativity and the diversity of the different approaches in fulfilling complex, mutually dependent tasks in a collaborative endeavor.

RATIONALE

Up to now only a few surveys have investigated ways improving the image of physics and chemistry; there has been no investigation in connection with out-of-school laboratories. Amongst others this survey will determine the effectiveness of an innovative out-of-school-laboratory on the image of 'hard' sciences.

METHODS

The development of the image of physics and chemistry is accomplished through a semantic differential according to the CAEB study (Stahl & Bromme, 2007; CAEB: An instrument of measuring connotative aspects of epistemological beliefs). The scale of the current study corresponds to the CAEB scale, but applies different adjective pairs in part to adapt to the special situation in the laboratory. It embraces seven pairs of adjectives on a six-step-scale: important-unimportant; productive-unproductive; creative-uncreative; dynamic-static; open-closed; progressive-regressive; innovative-conservative. The image of physics respectively chemistry as a school subject and as sciences is differentiated.

17 classes were tested in a pre-post-follow-up survey with paper and pencil. Around 300 mainly 16-18 years old students got the first questionnaire a few days before visiting Baylab plastics (T1). The second one was handed out right after their visit (T2), and the third three months later (T3).

The results are presented on scale and item level.

RESULTS

As shown in Figure 1, Baylab plastics has a significant influence on the image of physics and chemistry. Due to the lab intervention there is a strong shift of the images towards a higher activity level. However, the results are different with respect to the long term effects. Only the image change of physics as a science is stable for more than three months after the lab visit. All other image changes are only short term effects. They fall to lower activity level after the increase due to the lab intervention.

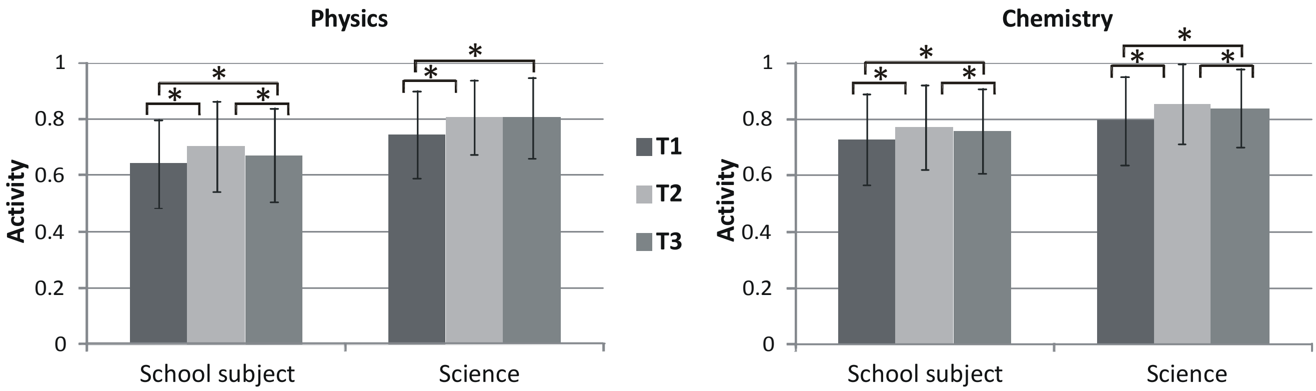

Fig. 1: Development of the image of physics and chemistry as a school subject and as a science

Moreover, both science subjects have a better image than the respective school subjects. The perception of the school subjects is developed and stabilized over many years. Presumably, it is influenced by the prevailing deductive teaching style. Apparently, this largely top-down transmissive and reproductive method conveys an image with a lower activity level. The students clearly differentiate between school and science subjects: the image of the sciences has a more positive connotation; the activity level is higher.

Comparing physics and chemistry, the image of chemistry gets higher scores. This is largely a result of the chemistry focus of the classes. As Baylab plastics is related with chemical industry, mostly chemically oriented teachers opt for visiting the lab with their classes. From this background it is interesting to note that the lab changes the image of physics more deeply than the image of chemistry. This may be due to the fact that the lab involves more physics-related activities (e.g. testing, quality control, technology) than anticipated by the visitors. The effect sizes are small to medium (T1 to T2: d=0.38 for physics as a school subject, d=0.43 for physics as a science, d=0.28 for chemistry as a school subject, d=0.43 for chemistry as a science).
The effects on item level are shown in Fig. 2 and Fig. 3. Especially, for the creative and dynamic related dimensions there is a strong shift of the images towards the positive at the end of the lab visit. For both sciences this effect is for long term. Furthermore, the improved image of physics as science remains stable for more than three months after the lab visit. This refers to the items productive, creative, dynamic, open and innovative. Similarly, the image of chemistry as a science improves significantly. However, a shift backwards to the initial image at T1 is obvious.

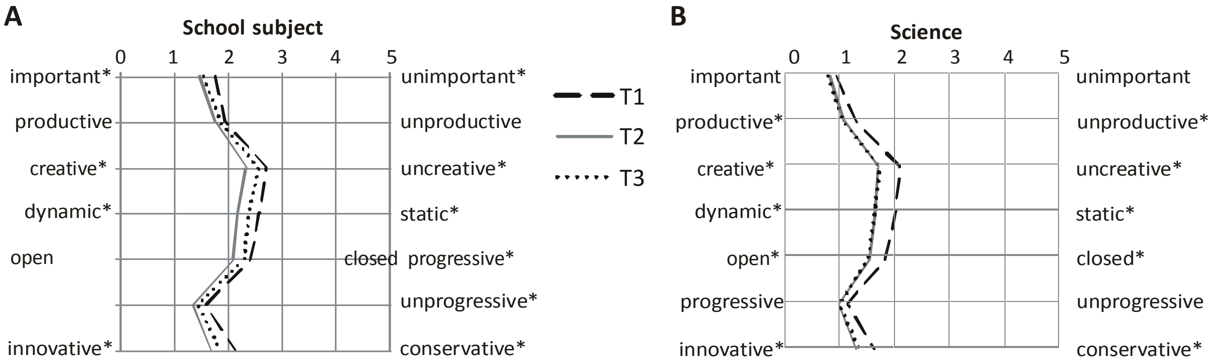

Fig. 2: The image of physics as a school subject (A) and as a science (B), all items individual

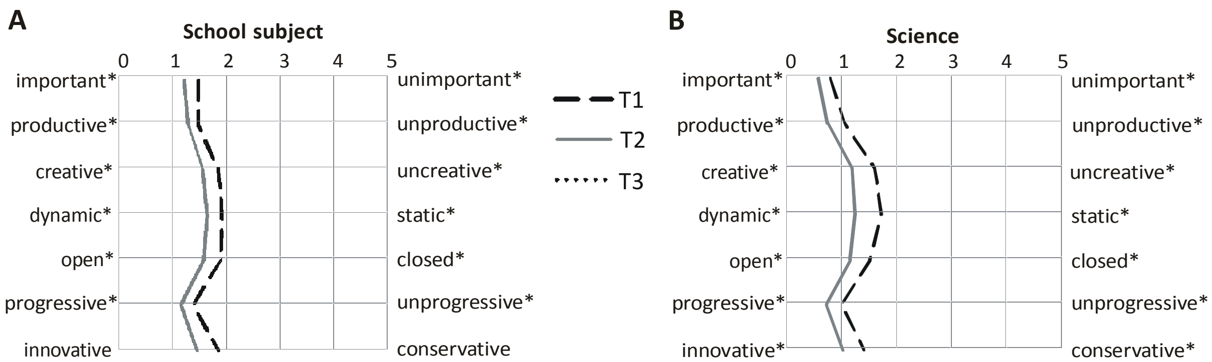

Fig. 3: The image of chemistry as a school subject (A) and as a science (B), all items individual

The results on scale level show more positive scores for the sciences. This can be replicated on item level for every single item. After the intervention the image of the school subjects starts to revert into direction of the first image at T1. Apparently the school subject cannot retain the improved image.

In summary, practical work in an industry context seem to affect the dynamic and creative related aspects of physics and chemistry. After visiting the Baylab plastics the students perceive the hard sciences as a more creative and dynamic field. The lab experience promotes far-reaching and partly sustainable changes of the image.

CONCLUSIONS AND IMPLICATIONS

In addition to existing studies that investigated the development of interest after visiting an out-of-school-laboratory (for example Engeln, 2004; Pawek, 2009), this study investigates ways of changing the image of physics and chemistry both as a school and as a science subject. Baylab plastics fosters an active engagement with science and technology. Practitioners from industry and students are brought together in an authentic science context and learning opportunities complementary to students' school experience are provided. In this context new innovative approaches of experience-based learning in the work place are presented and discussed.

Selected results reveal a positive impact of Baylab plastics on the image of physics and chemistry. This learning laboratory significantly improves the image of physics and chemistry particularly with respect to the creative and dynamic dimensions with a stable long term effect especially for physics. Even single one-day visit at the lab is able to change stereotype views of the hard sciences. The results also reveal differences between the image of the school and science subjects. Apparently the school subjects cannot retain the improved image. Future studies should focus on how to profit from possible image changes in school.

As this very special learning experience in industry facilitates a significant image change it could serve as a model for further interventions. It is desirable that in the near future more activities along similar guiding lines may contribute to increase the attractiveness of professions related to science and technology and may help to reduce the lack of skilled personnel in science and technology related positions.

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IMPLEMENTATION OF INQUIRY-BASED LEARNING IN GERMAN SCHOOL PRACTICE

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Abstract: There are many projects in Europe focusing on changes in methods of teaching mathematics and sciences. One of them is called COMPASS – Common Problem Solving Strategies as Links between Mathematics and Science. In COMPASS new teaching materials are developed and evaluated. Following the COMPASS philosophy, students learn to tackle problems, understand phenomena, find and explain solution strategies solitary as well as in teams. COMPASS is guided by the two central themes of intertwining mathematics and the sciences and paying special attention to socially relevant topics in its teaching modules. COMPASS is a transnational project which is funded by the European Union. The major research interest of the German project team is directed to the constraints and supporting conditions for the implementation of inquiry-based learning strategies in class. This paper introduces to the concept of COMPASS in Germany, and the approach of teachers' professional development applied in the project. It elaborates on the evaluation design and presents first results of the studies.

Keywords: Inquiry based learning · intervention study · teacher professional development · science learning · scientific process skills

BACKGROUND

The professional world places high demands on young people and graduates. Therefore students should not only study mathematics and sciences on a mere content level. It's a both demanding and significant additional learning objective of science and mathematics classes to learn and identify problems, understand phenomena and find solution strategies both solitary, and as members of a team. Students need to be able to quest for and select information, develop solution strategies, and explain them to others. In order to achieve this, a change in teaching and learning behaviours must take place. Our approach of inquiry-based learning is at its heard multidisciplinary. Challenging problems which are authentic from a scientific point of view and relevant to the students' daily lives are the nucleus of closely intertwined teaching modules in various subjects (most of all mathematics and the sciences) that contribute to the problem's solution. Dealing with challenging and relevant topics promotes lifelong learning in a knowledge society. It also fosters the ability to develop skills (e.g. softskills like team work competencies) and to attain and apply knowledge. In general, the main focus of COMPASS is on developing, testing and evaluating teaching materials for inquiry-based learning. Educational and empirical research offers many findings on contemporary and appropriate learning and teaching strategies in mathematics and the sciences. But evidently, a change in learning and teaching behaviour has not taken place (PISA, Rocard-Report, 2007). For this reason COMPASS is focused on the implementation of inquiry-based learning throughout Europe. COMPASS comprises six institutions from six European countries (Germany, Netherlands, Spain, Slovakia, Cyprus, United Kingdom). The project is managed and coordinated from Freiburg. The project was running from November 2009 to October 2011.

RATIONALE

Defining Inquiry Based Learning in terms of the COMPASS project

Educational and empirical research offer a wide range of approaches to inquiry-based learning. So there are many definitions of inquiry-based learning to be found (e.g. Dewey, 1910; Linn, Davis & Bell, 2004). It is therefore important to rely on one definition of inquiry-based learning within COMPASS. The definition, upon which COMPASS has agreed, is: *Inquiry-based learning includes many activities such as observing, asking questions, collecting available information (internet, literature), planning experiments, collecting, analysing and evaluating data, finding answers and explanations, presenting and explaining results. It is essential to formulate hypothesis, and to subsequently think critically and logically about given conditions and alternatives. Inquiry-based learning is based on the fact that students play the active role and learn to formulate their own hypothesis. Formal explanations follow the aforementioned activities.* Merging mathematical and scientific approaches in terms of interdisciplinary working methods is an additional key characteristic of inquiry-based learning. According to this definition COMPASS materials rely on an inquiry-based learning approach.

Implementation of COMPASS materials in Germany

As already outlined the central objective of the project is to evolve the teachers' thinking about teaching and learning mathematics and science as well as to improve the range and quality of their teaching behaviour by developing teaching and learning methods. To develop teachers' ways of thinking about "high quality" teaching practice in the sense of inquiry-based learning, we draw on theoretical and conceptual frameworks that address teacher competencies, such as Shulman's (1987) approach of "content specific pedagogical knowledge" (PCK) or the Model of Educational Reconstruction (Duit et al., 2005) and we refer to results of programs like SINUS or Physics in Contexts (see Ostermeier et al., 2010 or Author, 2010). Furthermore teacher training offers the opportunity for teachers to test and learn how to change school practice by using COMPASS materials in class. Within the scope of the project teachers work closely together with mathematics and science educators. The cooperation between teachers and educators is viewed as "symbiotic". This means that teachers are seen as experts in the field of practice whereas Mathematics and science educators are familiar with recent research literature and innovative instructional methods. The role of the educators is to serve as coaches guiding the work in "communities of practice" made up of teachers and educators. We expect a close cooperation between teachers and educators supporting a successful implementation of COMPASS materials in school practice.

The tripartite school system in Germany poses a great challenge because according to their level of performance students are taught in different types of schools for the low (Hauptschule), average (Realschule) and high achieving students (Gymnasium). Therefore it is required to develop three types of materials according to the various levels of performance. The prevailing conditions can vary greatly from school to school. An analysis of needs conducted in daily school life draws a fairly heterogeneous picture. All three types of schools offer the opportunity for interdisciplinary learning in terms of inquiry-based learning. Especially in the case of schools for the lower and average achieving students (Hauptschule, Realschule) some traditional school subjects were replaced by subject clusters (e.g. subject cluster science). This trend differs from the one that is evident in Gymnasiums. In a survey of 50 teachers, all teachers stated that the contextual framework has a favourable effect on the implementation of COMPASS materials in mathematics and science classes. Nonetheless the teachers did not feel comfortable and prepared to teach while applying such methods. They furthermore claimed that they did not know of any successfully tested and reliable teaching materials. This is where COMPASS applies.

METHODS

Projects like COMPASS require an evaluation. Evaluation research offers quite a number of evaluation standards as well as reliable evaluation models. Stufflebeam (1974) introduced the CIPP model of curriculum evaluation, which includes context evaluation, input evaluation, process evaluation and product evaluation. This framework provides a concrete foundation in situations where decisions have to be made. Our evaluation approach is oriented towards the CIPP model. The following research questions are relevant to the COMPASS project:

1. *Questions concerning the implementation:* How do teachers accept the materials? In which ways do teachers implement the materials in their daily teaching practice? Which supporting and or hindering factors concerning the implementation could be identified?
2. *Questions concerning the teachers:* What are the project-related expectations and interests of teachers, participating in the COMPASS activities? What are their beliefs in the fields of inquiry-based learning and interdisciplinary approaches of teaching and learning? To what extent do they benefit from this project? In which ways do beliefs just as well as instructional practices change during the lifetime of the project and due to the application of COMPASS materials?
3. *Questions concerning students:* To what extent and how do students perceive inquiry-based learning? Do they develop new perceptions of mathematics and sciences? Do students develop adequate competencies in the area of working like a scientist?

A successful evaluation includes formative and summative aspects and employs a mixed-methods-design (qualitative and quantitative analysis). Formative evaluation supports and documents the implementation process at different levels. Summative evaluation investigates the implementation of inquiry-based learning on a European level and potential development of students' and teachers' competencies. The analysis is based on teacher and student data, which were collected in pilot schools.

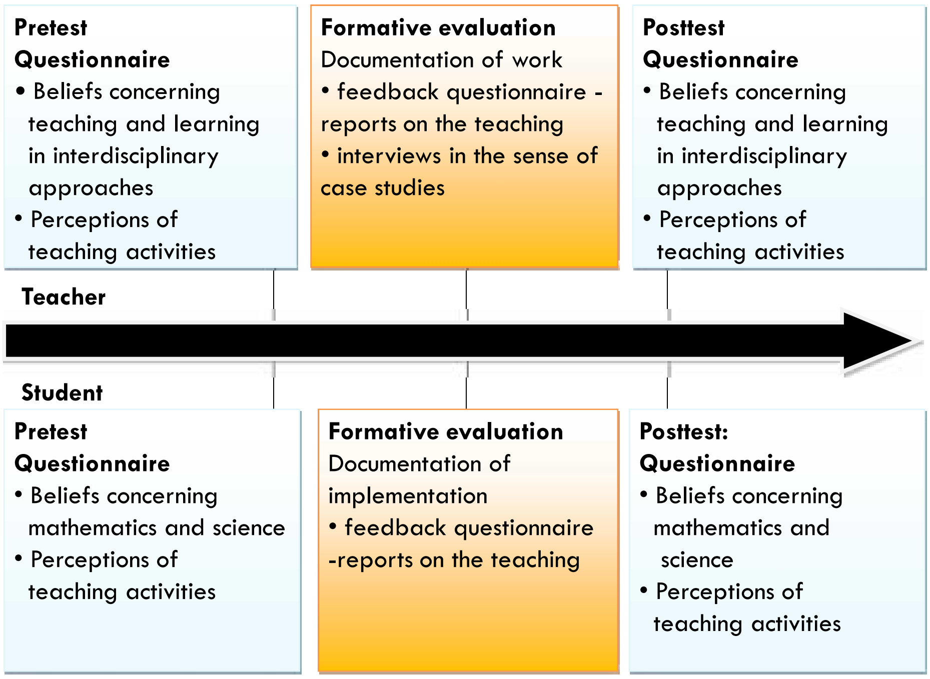


Fig. 1: Design of evaluation

Focus on teachers: On the teachers' side, a questionnaire is administered which aims at various aspects of interdisciplinary teaching and the teachers' related beliefs and self-directed perceptions of instructional practices. The teachers who took part in the survey were asked to fill in the questionnaire at the beginning and the end of testing Compass materials.

In addition, we document the implementation process in the participating countries. We also ask teachers to provide information on their acceptance of the Compass units.

Focus on students: A students' questionnaire was employed at the beginning and at the end of the testing process. The aim was to analyse students' beliefs concerning mathematics and science. In addition we wanted to know whether the perceived teaching practice from the students' perspectives changes from the beginning to the end of the testing process. We used additional questionnaires to have a feedback from the students on the Compass unit.

SELECTED RESULTS

The materials and teaching units were tested by different teachers in every country participating in the COMPASS project. Selected results are presented and discussed in the following.

The COMPASS units are based on the blending of science and mathematics content relating it to everyday contexts which are relevant to the students. Furthermore the COMPASS units take inquiry- and modelling-oriented approaches into account. Relevant societal problems play an important role. Hence, the Compass units aim at fostering the students' ability of critical argumentation.

Our hypotheses for the evaluation study are:

1) The specific characteristics of the COMPASS units have a positive effect on the students' motivation to deal with science and mathematics.
2) Compared to regular teaching practices COMPASS units lead to more open and student centred teaching activities.

Changes in students' beliefs

Expecting changes in students´ attitudes based on the specific characteristics of the COMPASS units we supposed a positive influence on the students' motivation. We were able to develop two adequate motivation scales of high reliability.

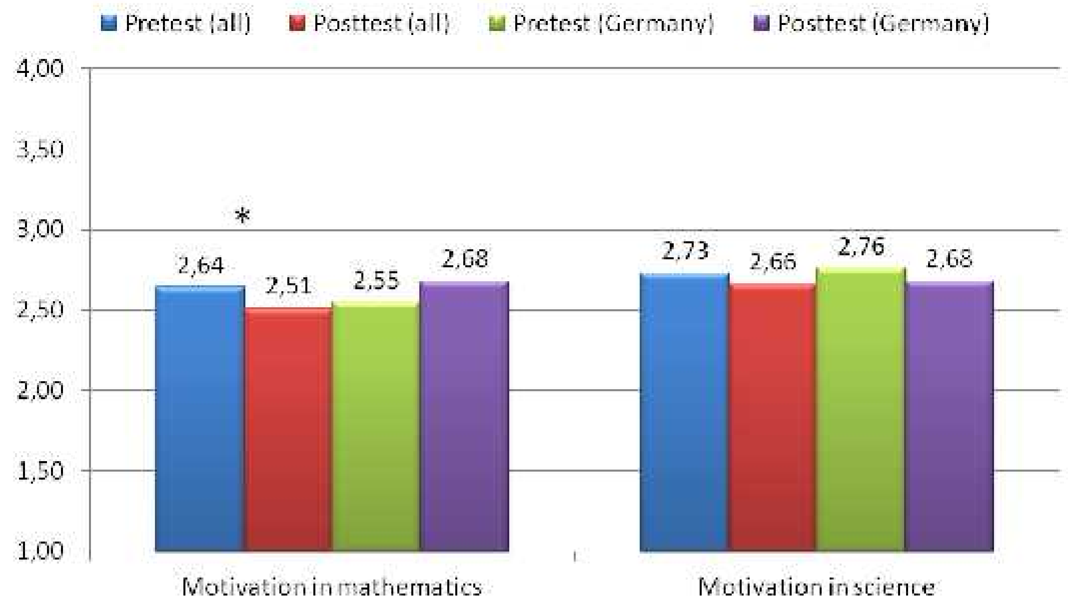
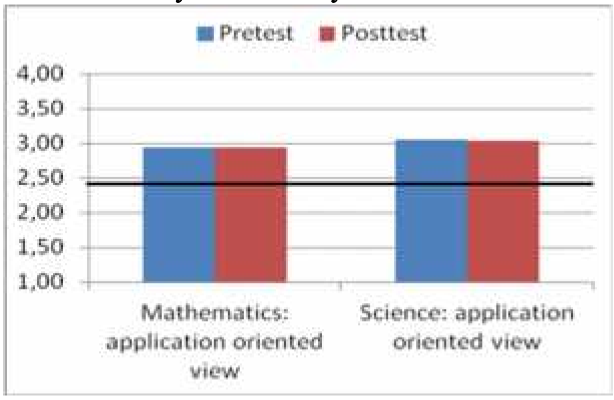


Fig. 2: Students´ motivation

Regarding the whole sample the motivation in mathematics decreases significantly. This is due to the significant decrease regarding the boys, whereas the girls' motivation is stable. In Germany, the mean value of motivation in mathematics does not change significantly between pre- and post-test.

With respect to science the motivation is stable. There is no significant difference between motivation in mathematics and science in pre- and post-test. Furthermore, we were able to develop two adequate scales concerning application oriented views. The reliability of these scales is also very satisfactory.



	Mathematics: application oriented view	Science: application oriented view
Pretest	M=2,95 SD=0,77	M=3,06 SD=0,47
Posttest	M=2,94 SD=0,79	M=3,04 SD=0,47

Fig. 3: Application oriented view in mathematics and science

The results shown in figure 3 indicate that in the field of application oriented views the students` already hold adequate beliefs. Hence there are no significant changes in these beliefs between pre- and post-test. There are neither country specific nor subject specific effects.

Changes in teaching behaviour

To what extend do instructional practices change during the lifetime of the project and due to the application of COMPASS materials? Can we observe differences between mathematics and science?

In the first step, we developed three scales each analysing the teaching practices in both mathematics and science. These scales show satisfactory reliabilities and were used in the teachers´ and students´ questionnaires. The following table presents the results concerning the perceived teaching practices from the students' and the changes from the beginning to the end of the testing process.

	Student-centred methods (in Math)	Discussion culture (in Math)	Application oriented teaching (in Math)
pretest	M=2,59 SD=0,65	M=2,59 SD=0,80	M=2,15 SD=0,66
posttest	M=2,78 SD=0,55	M=2,63 SD=0,79	M=2,35 SD=0,62

Table: Students´ estimation of teaching behaviour (Likert scales, 1 .. disagree and 4 .. agree)

In the scales "student-centred methods in mathematics" and "application oriented teaching in mathematics", there are significant increases in the "paneuropean" sample. Self-responsible learning and student-centred methods are paid substantial attention in the COMPASS units. Here, we find a significant increase over the mean value of this scale. Application oriented teaching also plays an important role in the COMPASS philosophy. The mean value of this scale increases significantly. Same effects can be found regarding the German COMPASS schools.

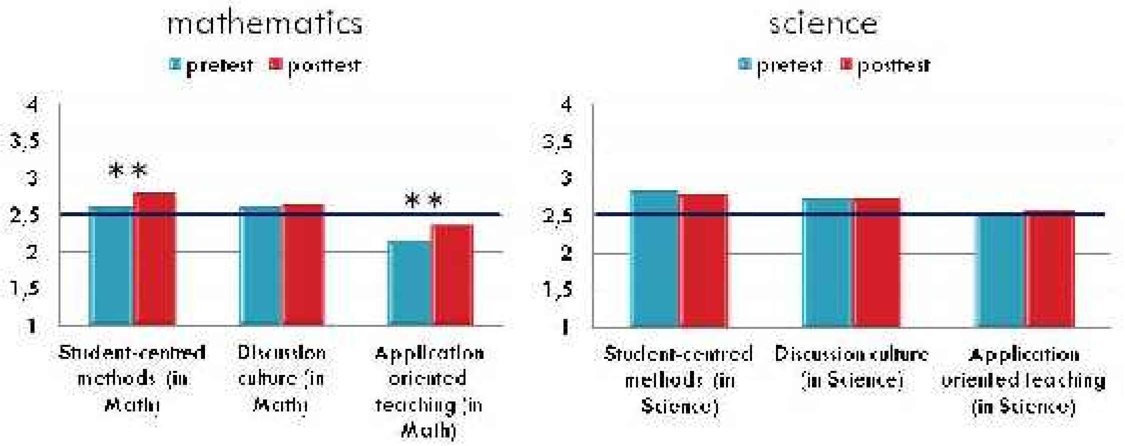


Fig. 4: Students´ estimations on teaching behaviour

As expected, there are significant differences between teaching behaviour in mathematics and teaching behaviour in science. Compared to mathematics in two scales the mean values are on a higher level in science: Teaching practices in science tend to be more student-centred and application oriented as opposed to the teaching in mathematics. On a high level there are no changes in the science scales.

CONCLUSIONS

All in all it can be stated that the COMPASS materials were well received by the participating teachers. Science teachers just as well as mathematics teachers report a significant impact of COMPASS materials on their teaching. The students however tended to perceive significant changes in the teaching practices mainly with respect to their mathematics classes. Hence it is most of all mathematics that benefits as a school subject from the ideas which are inherent to the COMPASS units.

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BRAIN TYPE, SEX DIFFERENCES, AND MOTIVATION TO LEARN SCIENCE: A CROSS-CULTURAL STUDY

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Abstract: Sex is considered to be one of the most significant factors influencing attitudes towards science. However, the so-called brain type approach from cognitive science suggests that the difference in motivation to learn science does not primarily differentiate the girls from the boys, but rather the so-called systemisers from the empathizers. Boys are, on average, more motivated to learn science, not because they are boys but because boys tend to be systemizers, and *vice versa* for girls. Previous research on Swiss students has indeed shown full mediation between sex and motivation to learn science. The present study was conducted in order to confirm this relation in a cross-cultural study. It involved four countries (Malaysia, Slovenia, Switzerland, and Turkey) and 1200 students in upper secondary level. The study used structural equation modelling in order to test the hypothesised relationship. The results confirm the full mediation of systemizing between sex and motivation to learn science. The results are stable and the model fit is excellent. Systemizing explains 27% of the motivation to learn science. The indirect impact of sex on motivation is significant but low. The results are invariant across all four cultures. It is therefore concluded that students' brain type, seen as a basic cognitive personal trait, is more important as a predicator for motivation to learn science than sex. It should be taken into account both in science teaching and research of science education.

Keywords: Gender, Sex, Motivation, Culture, Cognition

INTRODUCTION

A number of studies indicate that boys have a more positive attitude towards science education than girls and this trend is seen most profoundly in studies which do not differentiate between science subjects but rather investigate the general attitude of students toward science lessons (Osborne & Collins, 2003; Sjøberg & Schreiner, 2005).

If, however, studies focus on students' interest and motivation to learn science, the situation becomes less clear. Glynn, Taasoobshirazi, & Brickman (2007), for example, were unable to find a relationship between sex and motivation to learn science among American students with non-science majors. This ambivalence is also salient, when subdimensions of motivation are taken into account. For example Britner's study (2008) found that girls had stronger self-efficacy in science classes, particularly in earth and environmental sciences, while other studies reported a reverse result (cf. Glynn, Taasoobshirazi, & Brickman, 2009).

In this unclear situation, research results from cognitive science, provided by Billington,

Baron-Cohen, & Wheelwright (2007), is of particular interest. These researchers compared natural science and human science students in view of their sex and their so-called brain type. They showed that male sex was indeed a statistical predictor for studying natural science. However, the brain type had a far greater influence on the path of study than sex.
The concept of brain type was originally formed within the field of autism research (Baron-Cohen, 2002). Baron-Cohen and colleagues developed a cognition concept by proposing the interplay of two core psychological dimensions: empathizing (E) and systemizing (S) (Baron-Cohen, Knickmeyer, & Belmonte, 2005). The brain type is defined as the interplay between the two abilities. There exists a score EQ (empathy quotient) and a score SQ (systemizing quotient) to measure the empathizing and the systemizing dimensions respectively. Brain type is basically calculated as a mathematically normalized difference of EQ and SQ.
Based on their results, Billington et al. (2007) suggested that perceptions toward natural science are fundamentally influenced by brain type rather than by sex. Thus, the difference between motivation for learning science does not primarily differentiate the girls from the boys, but rather the systemizers from the empathizers. The difference observed between the sexes results from the tendency for girls to be empathizers and the boys to be systemizers and from the finding that systemizers, in general, are more interested in natural sciences than the empathizers.
This hypothesis has recently been tested by research on Swiss students (Zeyer, 2010; Zeyer, Bölsterli, Brovelli & Odermatt, in press; Zeyer & Wolf, 2010). Structural equation modeling indeed showed full mediation of systemizing (one of the cognitive dimensions of the brain type) between sex and motivation to learn science. This means that sex had no direct impact on motivation to learn science, but only through its impact on systemizing, which itself explained 25% of motivation to learn science. However, results differed from expectations since there was no relation between empathizing (the second cognitive dimension of the brain type) and motivation to learn science.
The interesting and open question remained, were these relations between sex, empathizing and sytemizing, and motivation to learn science were specific for the Swiss science education culture, or were they indeed applicable and constant across other cultures. The present study was conducted in order to investigate this research question in a cross-cultural setting. The study involved four countries (Malaysia, Slovenia, Switzerland, and Turkey) and 1300 students in upper secondary level.
Structural equation modeling was used in this study in order to confirm the hypothesized relationship in the overall sample and in each of the involved cultures.

THEORETICAL BACKGROUND

Brain type

The Brain Type Theory initially emerged from a theoretically and empirically substantiated concept from Baron-Cohen and colleagues (2005). In this theory, two fundamental psychological dimensions are proposed: systemizing and empathizing (Billington et al., 2007). These relate respectively to the “consciousness of a physical world” and to the “consciousness of a mental world” (Baron-Cohen, 1999).
The basic principle of the brain type theory is that each human uses both of the available psychological dimensions systemizing and empathizing. Generally, however, one of the dimensions, systemizing or empathizing, is predominant. A person who is more influenced by systemizing than by empathizing is described as a systemizer. In the reverse case, a person is called an empathizer. People who are equipped equally with both abilities are called balanced. This concept is known as the E-S-Model.

An important result from the research, which arises from using the E-S-model is that women are on average empathizers (that is their normalized Empathizing Quotient is in general larger than the normalized Systematizing Quotient, E > S). Men are on average systemizers (S > E) (Baron-Cohen, 2002). However, this generalization is only applicable on average as there are also systemizers among the women and empathizers among the men.

Motivation to Learn Science

The central focus in motivation research is on the conditions and processes that facilitate the students' persistence, performance and healthy personal development (Ryan and Deci, 2009). In the study presented here, we use Glynn and Koballa's theoretical motivation framework (2006) to ensure comparability with their results. Thus motivation is defined as "… the internal state that arouses, directs, and sustains students' behavior towards achieving certain goals. In studying the motivation to learn science, researchers attempt to explain why students strive for particular goals, how intensively they strive, how long they strive, and what feelings and emotions characterize them in this process" (Glynn & Koballa, 2006, p. 1090). Based on research within the social-cognitive motivational framework (Bandura, 2001), Glen and colleagues identify six important motivational constructs that include intrinsic and extrinsic motivation, relevance to personal goals, self-determination, self-efficacy, and assessment anxiety (Glynn & Koballa, 2006).

The Questionnaire

In part A of our questionnaire, we used the SQ and the EQ questionnaire by Baron-Cohen (2003). Each country translated the questionnaire into its own language. Both the SQ and the EQ questionnaires contain 60-items in forced choice format, comprising 40 cognitive style items and 20 control items. The SQ includes questions such as "If I had a collection (e.g. coins, CDs, stamps), it would be highly organized" and "When I learn a language I become intrigued by grammatical rules". Similarly, the EQ includes items such as "I am good at predicting what someone will do" to measure cognitive empathy or "I usually stay emotionally detached while watching a film" to measure the affective component of empathy.

On both the EQ and the SQ questionnaires, participants are asked to respond on a four-point Likert scale with "definitely agree", "slightly agree", "slightly disagree" or "definitely disagree", and approximately half the items are reverse scored to avoid response bias.

In Part B of the questionnaire, we asked students to respond to the 30 items of the Science Motivation Questionnaire (SMQ; (Glynn & Koballa, 2006)). The items were translated into German. The SMQ items were developed based on the motivation concepts described earlier in this article. Students respond to each of the 30 randomly ordered items on a 5-point Likert type scale ranging from 1 (never) to 5 (always). Anxiety about science assessment items are reverse scored when added to the total, so a higher score on this component means less anxiety.

METHOD AND SAMPLE

A total of 1300 students from four countries, i.e. Malaysia, Slovenia, Switzerland, and Turkey were investigated. After cleaning the raw data, the sample included 1188 students, 476 male students (40.1%) and 712 female students (59.9%). The mean age was m_{age}=16.59 years (SD=.905). The distribution of the students in the different countries is indicated in Table 1.

The students were visited in their classes. For the duration of two lessons, students were required to be fully involved in the research by filling out the questionnaires. They were informed that a study was being conducted to further understand students' motivation to take science classes. Thereafter, the general conditions for the research were presented and finally, the questionnaires were distributed. The students had a break in between filling out each of the questionnaires and then the completed questionnaires were collected. In each class, the same standardized process was adhered to.

Table 1
The structure of the sample by the countries

	Malaysia	Slovenia	Turkey	Switzerland
Male	126	107	119	124
Female	159	218	142	193
Total	285	325	261	317

RESULTS

The procedure of structural modeling

For the simultaneous test of the structural and measurement hypotheses, a causal structure was posited among the concepts of the EQ and the SQ, the SMQ, and sex. The tested structural equation model reflects the hypothesis that engagement in science is influenced by the SQ and by the EQ, and that sex only has an indirect (mimic) effect on the engagement in science through its impact on the two latent variables EQ and SQ. The model is a first order model, that is, the second order construct of brain type has not been introduced in the model.

Item Reduction

In order to be able to include SQ, EQ, and SMQ as single latent variables into the model, each of them had to undergo a substantial item reduction. Given the sample size and the number of SMQ items, 12-15 items at most for the structural model seemed to be adequate (Kim, 2005). Concerning the unidimensional item sets of EQ and SQ, a random assignment method was used (Little, Cunningham, Shahar, & Widaman, 2002). Each item from the EQ resp. the SQ was randomly and without replacement assigned to three parcels. This method is appropriate when items stem from a common pool, as it is the case for questionnaire items like those in the EQ resp. the SQ questionnaire.
A domain-representative approach was used for the SMQ, a multidimensional item set. With this method, parcels are constructed by combining items from different dimensions into item sets. It attempts to account for multidimensionality by creating parcels that encompass not only the common variance, but also the reliable unique facets of the multiple dimensions. Given that each of the six subdomain of the SMQ consists of five items, the domain-representative approach produced five parcels of six items each stemming from the different subdomains.

Model Confirmation

Due to the complexity of the empirical test, a two-step process was employed to confirm the first order model. All the estimates were produced using AMOS 16.0 (Airbuckle, 1997) and the estimation method of maximum-likelihood. As a first step, the measurement models of the EQ, the SQ and the SMQ were tested through confirmatory factor analysis. As discussed in subsection 2.1.3, three random parcels of the SQ items resp. the EQ items and five domain-representative parcels of the SQM items were used to operationalize the three latent variables. In the second step, the full structural model was directly tested. It reflects the core hypothesis of this study that the SQ and also the EQ have an impact on each PISA key concept of engagement in science, and that the impact of sex is only indirect (mimic) via the EQ and the SQ.

The full structural model

After an intensive analysis of the modification indices, significance tests, standard errors, and several intermediate model modifications, the structural equation model in Figure 1 is regarded as the best fit for the data.

The definitive model has undergone important structural modifications. A salient feature is the complete absence of the EQ, the empathizing quotient, in the diagram. This latent variable indeed showed only small and non-significant loadings on all other latent variables in the model. Sex also had no impact on the EQ. Its removal entailed an improved overall fit.

The factor loadings of the remaining measurement instruments are statistically highly significant ($p<.01$) and the corresponding signs concur with the hypotheses. The standardized estimates, from .74 to .89, confirm the formal validity of the individual items (see Bollen, 2002). The explained variances of the items vary between .54 and .79; this is a highly acceptable range of magnitudes. Descriptively, the model works very well which is indicated firstly by a highly acceptable goodness of fit index (GFI) of .982. Secondly, the baseline comparison (CFI) is 0.987. From an inferential point of view, the model is compatible with the data (CMIN/DF=3.876). Finally, RMSEA<.49 and PCLOSE=.530 indicate a very good fit (for the fit measures see Arbuckle, 1997, p. 551ff).

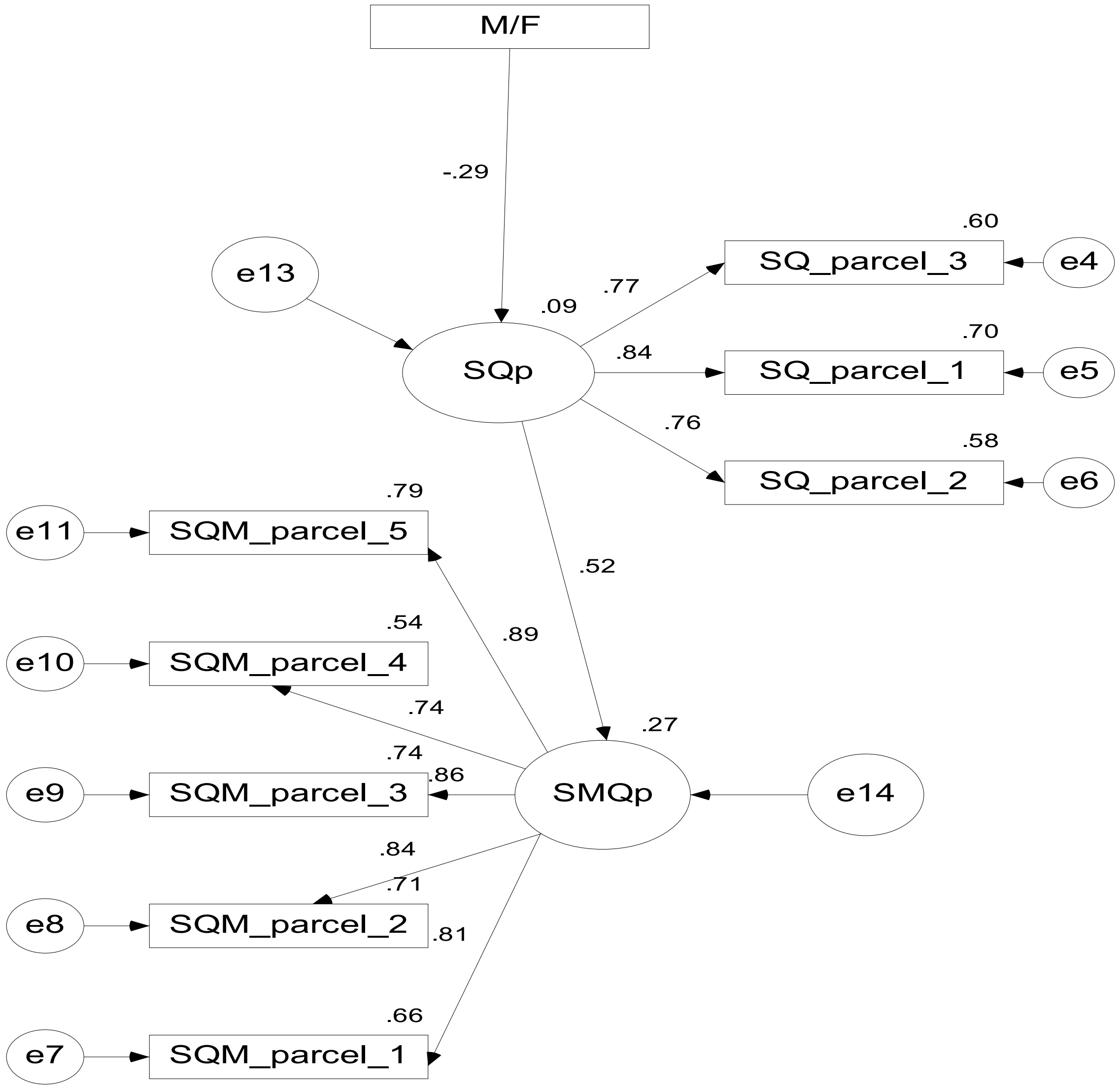
The standardized regression weight of the SQ on the SMQ (.52) is considerably high. Thus, the explanatory power of the model is high. The impact of the SQ can explain 27% of the variation of the SMQ.

There is also a highly significant factor loading of sex on the SQ. The standardized regression weight is negative (-.29) because this variable represents “female” by the value 1, while 0 represents “male.” Therefore, in this model, males have a higher SQ (which aligns with the result in the descriptive part of this study). The impact of sex explains 9% of the variation of the SQ.

Given the good fit, the high amount of multiple square correlations, the high, equally distributed and highly significant factor loadings, this model is considered to be appropriate as a full model for the presented theory. It reflects the theoretical background of the brain type theory. It confirms the hypothesis that motivation to learn science is highly influenced by the systemizing cognition, while the EQ, representing the empathizing cognition, has no significant influence on this motivation. It also confirms the hypothesis that sex indirectly affects the motivation to learn science via the SQ.

The indirect effect of sex was calculated by bootstrapping. The standardized indirect effect of sex on the SMQ (-.152) is highly significant, but very small. Since there is no significant direct loading of sex on the SMQ, the effect of sex on the motivation to learn science is strictly indirect and minimal.

Figure 1
The full structural model. Standardized estimates.



Group comparison between male and female students

In order to compare the results of the different cultures, the method of simultaneous multiple group comparison was used, which allows an examination of the structure of the causal relations in both the measurement and the structural model (see Byrne, 2010). Firstly, a configural model (with no equality constraints imposed) was created by introducing the four data sets of the four different cultures. As expected, it reproduced the goodness of fit results of the basic model (CFI=.993, RMSA=.019, PCLOSE=1). Therefore, the four cultural groups show a comparable model structure, i.e. configural invariance.
Secondly, the metric (measurement) and the scalar invariance (structural) models were created and tested for invariance. The fit of the measurement model was consistent with that of the configural model (CFI=.985; RMSEA = .025). The difference in the comparative fit

ΔCFI=.008 is smaller than .01, which accepts the invariance hypothesis (Cheung & Rensvold, 2002). The model therefore shows metric invariance. The fit of the structural model was also consistent with that of the configural model (CFI=.911; RMSEA = .056). Therefore, the intercepts were released in both SQ and SMQ, for one resp. three indicators. The released model presented a much better fit (CFI=.979, RMSEA=.028), and the CFI difference test now yielded ΔCFI = .006), which accepted the hypothesis of partial scalar invariance. Therefore, it was concluded that the multiple group model displayed partial scalar invariance, which allows for a comparison of factor loadings and latent means between the four groups (Steenkamp & Baumgartner, 1998). Table 2 shows the squared multiple correlations and the implied means of the SMQ, and the means of the SQ for all four cultures.

Table 2.
Cross cultural comparison of the squared multiple correlations (SMC) and the latent means (means)

	SMC SQ	SMC SMQ	mean SQ	mean SMQ
Switzerland	.18	.3	7.27	16.55
Turkey	.03	.47	10.08	16.05
Malaysia	.05	.29	10.22	14.01
Slovenia	.13	.25	8.89	14.62

The difference between the impacts of sex on the SQ across the cultures is not significant. The same holds for the impacts of the SQ on the SMQ. It is the same across all the involved cultures. The difference of the mean SMQ across the cultures is not significant, neither. The only significant difference can be found between the mean SQs. The Swiss mean SQ is the lowest, followed by the mean SQ in Slovenia ($p<.01$). The mean SQs of Turkey and Malaysia are higher, but equal.

DISCUSSION

The Structural Equation Modeling (SEM) part of the results provides a structural model that reflects and confirms the theoretical background of the E-S theory and confirms the results of the previous Swiss studies (Zeyer, 2010; Zeyer, Bölsterli, Brovelli & Odermatt, in press; Zeyer & Wolf, 2010) in a cross-cultural context. As in the Swiss studies, three salient aspects are included in the model: the impact of the SQ on the engagement in science, the absence of an impact of the EQ on the engagement in science, and the strictly indirect influence of sex on E-S. These features are remarkably the same in all four cultures. The only significant difference can be found in the means of the SQ, which is lowest among Swiss students.
The impact of the SQ on motivation to learn science is fairly large. The more somebody systemizes, the greater their motivation to learn science will be. Secondly, the structural model suggests that the EQ does not influence the engagement in science. Empathizing is defined as a drive to identify another person's mental state and to respond to a mental state with one from a range of appropriate emotions. Significantly, the personal disposition to empathize seems to have no influence on a person's motivation to learn science. This partially corrects the hypothesis suggested in the work of Billington et al. (2007). If brain type were to influence a person's motivation to learn science, then not only the SQ but also the EQ would be involved. Since brain type is essentially calculated as the difference between the SQ and the EQ, a positive effect of the brain type on the motivation to learn science would imply a negative effect of the EQ on these constructs. Such a negative effect could indeed be motivated

from a theoretical point of view. If empathizing is the drive to deal with mental states, it could well be that a strong interest in mental things could simultaneously diminish engagement in science, at least with science that is explicitly dedicated to physical things.
However, in the structural model presented in this article, this is not the case. Instead, motivation to learn science is independent of a person's drive to empathize. A strong empathizer can be poorly engaged in science; however, their engagement can also be strong. It depends on their SQ. The inverse holds true, i.e. for a low empathizer. This can be interpreted in two different ways. Firstly, one could argue (based on the aforementioned reflections) that general science simply has no link to empathizing at all and therefore, it does not affect the empathizing cognition of a person whatsoever. Another point of view could be that the empathizing dimension of students is not affected because of the particular way general science is taught in the investigated schools (or at least it has no negative impact as suggested by previous research, which could also be taken as a positive point). From the presented data, it is not possible to determine which interpretation is correct.
The third salient feature of our model is that sex only has an indirect (mimic) effect on the motivation to learn science. This is in fact the core hypothesis derived from the findings of Billington et al. (2007) and it is the main motivation for the investigations presented in this paper. The argument follows: engagement in science depends primarily on the SQ of a person. If the systemizing cognition of a student is strong, then they will show a high engagement in science independent of their sex. Since men tend to be stronger systemizers than women, men are prone to be more engaged in science. However, if a man is a weak systemizer, he will not be engaged in science despite his sex. On average, men are more motivated to study science than women, because they are, on average, stronger systemizers. In terms of empathizing, the same holds true for women who are more likely to be less systemizing.

CONCLUSIONS

Overall, the present structural equation model suggests a clear situation. The motivation to learn science is directly and fairly strongly influenced by the SQ and indirectly and very weakly influenced by sex. The study confirms the Swiss results and shows a remarkable stability across four different cultures. Indeed, studies by Wakabayashi, Baron-Cohen, Uchiyama, Yoshida and Wheelwright (2007) have already shown a cross-cultural stability of the E-S theory which fits satisfactorily into their biological framework. Empathizing and systemizing are, according to Baron-Cohen, not cognitive styles but biological abilities. This could explain the stability of our results across the cultures.
Generally, more research must be done to be able to reliably link our findings to the situation in the real science classroom. The challenge for school science seems to be determining how to teach low SQ students, whether they are good empathizers or not. It would be an interesting area of research to investigate how these two groups differ, and how they should be approached to improve the systemizing dimension of their cognitive style, i.e. their drive and ability to analyze the rules underlying a system in order to predict its behavior. The findings suggest that successfully improving the systemizing dimension of these students' cognitive style could consequently lead to improvements in their engagement in science. Research must show if and the extent to which the initial level of systemizing can be improved and how this might be achieved. Although cognition is biologically rooted, it does not mean that it must remain stable over time and inert to education. A second area of inquiry that remains seemingly uninvestigated is if the hypothesis holds true that science lessons do not affect the empathizing cognition of students.

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PART 3: TEACHING AND LEARNING SCIENCE

<u>Co-editors:</u> Marisa Michelini and Reiners Duit

Relations between teaching practices and student cognitive and affective development, planning teaching/learning intervention. Research based intervention and its role for curricula planning, instructional paths and learning outcomes, monitoring learning and its role in teaching practices, laboratory-based practice.

This part corresponds to strand 3. It contains 39 papers.

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TEACHING AND LEARNING SCIENCE

INVESTIGATING CLASSROOM ACTIVITIES: WHAT KIND OF INFORMATION DO WE GET – AND WHAT DO WE MISS?

Claudia von Aufschnaiter[1]
[1]Justus-Liebig-University Gießen

Abstract: Investigating classroom activities has become one major focus of science education research. It aims to describe patterns of instruction and teacher behavior and relates these descriptions to students' learning progress and students' interests in the subject. Also, such kind of research has become more prominent for investigating teacher profession. However, it has to be noted, that the majority of the projects focus on instruction whereas students' participation and meaning making while being exposed to this instruction is only rarely analyzed (in detail). Research reported draws on a single lesson about force in a grade 8 physics class. The lesson is used as an example to describe how patterns of instruction can be investigated and what kind of measures for instructional quality can be used (and why). The paper will also make an argument for a student focus while investigating instruction.

Keywords: Learning processes, video, classroom activities, instruction, physics

FRAMEWORK AND RESEARCH AIMS

Investigations of classroom activities serve at least two different purposes: They aim at analyzing instruction and its quality in order to gain information on how teaching is conducted and how specific patterns are related to student outcomes and their interest in a subject (e.g., Seidel & Prenzel, 2006). From these studies, research seeks information on "good" teaching. Also, analyses of classroom activities aim to identify teacher profession and how this profession relates to teacher self-reports on what they believe and do (e.g., Widodo, 2004). Results indicate that clear, structured and activating teaching has positive effects on student learning outcomes (e.g., Scheerens, 2008). However, it has to be noted that variables such as "clear" and "activating" are currently typically judged by an observer (based on a coding manual) without taking into account the students' reactions. When is a particular question "clear", "structured" and activating for students who are exposed to this question? Is a "clear" question "clear" to everyone in the class or just to a minority? In order to relate instruction to students' activities and their situated meaning making, the study reported in this paper utilizes criteria to describe instruction which has shown to be useful to describe students' learning processes. The study seeks to explore whether and how these criteria can be used to investigate teaching processes. Furthermore, it is explored how students respond to the instruction by using the same criteria in order to identify opportunities for student learning.

DATA AND METHODS

Data were obtained from physics lessons in Germany. In total, 13 teachers of grade 7 or 8 classes (students aged 13-14 years) participated. The first three lessons about either electric circuits or force were documented on video. In addition, the students completed questionnaires on their interests at the beginning and end of the school year as well as questionnaires on their experiences of single lessons. Pre and post measurements on students' achievements and in depths interviews with every teacher who participated were also conducted. For this paper, two teachers (teacher TB and teacher TS) were chosen who teach force in order to demonstrate methods of analyses used. These two teachers were also chosen because student data differed largely. For teacher TB student interest has not decreased much during a whole year (which is better than for all other teachers) but student do not show large learning gains. For teacher TS, the opposite occurred.

Data is investigated in several steps:

(1) Surface level coding of classroom activities (who is talking, teacher-centered vs. student-centered methods, experiment vs. theory, writing, reading, and so on, categories similar to those documented in e.g., Seidel & Prenzel, 2006). Examples of values with corresponding codes are given in Figure 1.

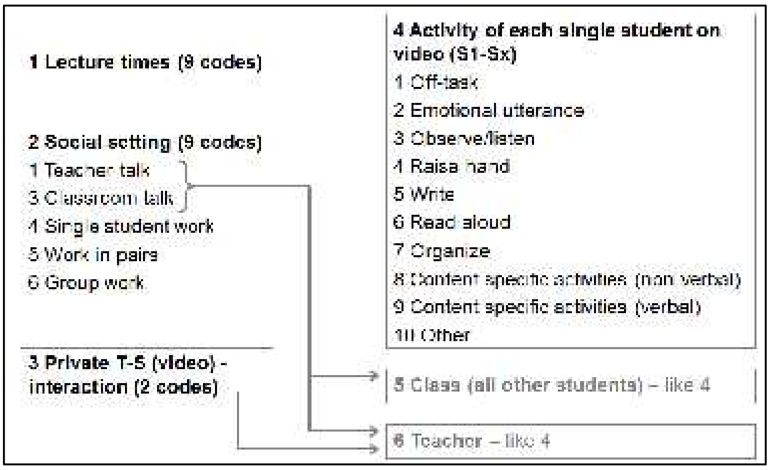

Figure 1. Codes for surface-level analysis of classroom activities. Some codes are coded only if other codes were applied (arrows). Each student on video is coded individually.

(2) Data is transcribed utterance by utterance including all activities relevant for the context such as writing or making use of experimental equipment but leaving out, for instance, activities needed to regulate the balance while sitting on a chair. In order to save time, sometimes those sequences are not transcribed in which only organizational activities (for instance, collecting or distributing experimental material) take place.

(3) Referring to a second order perspective (e.g., Marton & Booth, 1997) individual meaning is constructed from teachers' and students' utterances and activities. A "second order perspective" encompasses the idea that an observer tries to place him- or herself into the other's view to see the world through his or her eyes. This idea concurs with a constructivist notion as it emphasizes that we never really know the others' meanings but try to infer those from participants' activities. Even though we treat our constructions of teachers' and students' meaning as these were "true", we always have to keep in mind that they are only our construction of the others' constructions.

(4) Successive meanings which seem to develop a single idea are condensed to a "line of thought" (see example in Table 1). Those lines of thoughts are used as the basic unit for further analyses.

(5) Main categories for further analyses of lines of thoughts (see also: von Aufschnaiter, 2006; von Aufschnaiter & von Aufschnaiter, 2003; von Aufschnaiter & Rogge, 2010) are

Content: To get an overview about the content specific structure of lessons, content is investigated at different levels: Lines of thoughts are analyzed, sequences referring to the same area of content are identified, and sections comprising a specific topic of the lesson are counted (some results in Table 2). Also, the number of different content elements integrated into one line of thought can be investigated in order to gain information on content "width" of teacher and student talk.

Levels of abstraction or conceptual qualities: Lines of thoughts are assigned to different levels of abstraction (concrete, abstract-static, abstract-dynamic, e.g., von Aufschnaiter, 2006) or to different conceptual qualities (level I: explorative, level II: intuitive rule-based, level III: explicit rule-based with sub-level a) phenomenon-based concepts and sub-level b) model-based concepts, e.g. von Aufschnaiter & Rogge, 2010) in order to assess whether ideas are clearly based on conceptual understanding or seem to refer more to specific experiences indicating a limited understanding. Also, it is assessed whether the ideas are correct or incorrect.

Time: The duration of lines of thoughts, sequences, and sections can be measured in order to investigate the "speed" with which ideas are presented, answers are developed, contents change and so on.

Table 1
Time, transcript and line of thought

Time	Transcript	Line of thought
20 sec	T: O.k. Now we're talking about breakfast. Today, about one hour ago, some of you had breakfast to survive the day. You have to do it. Otherwise, something would be missing. What do you eat then, besides rolls and jam? Why do you it that?	Why do you have to eat rolls and jam for breakfast?

Depending on specific research questions, other codes can be applied to the data, too (for instance, describing student or teacher motivation), however, this will not be discussed in this paper.

RESULTS

A first impression of the videos indicates that the differences between the two teachers at a surface level are rather small: They both collect expressions with "force" in it and they distinguish between physics and non-physics forces. Their main lesson goal is the idea that forces change movement or shape. In order to reach this goal, some experiments, mainly demonstrations, are carried out in both classes.

During their lessons, both teachers were confronted with the distinction between force and energy. Whereas TB initiates the classroom discourse on the distinction himself, TS responds to a question a student has. Figure 2 shows all lines of thoughts TB (bold) and his students develop on this issue. Coherent lines of thoughts are condensed into sequences (horizontal line and duration for each sequence added). These sequences together form one section which is about "energy". For TS, the few coherent lines of thought on energy are part of the section "properties of physics forces". When responding to a student idea that the solar force is energy he uses less than TB the conceptual level IIIb which has shown to be difficult for students (e.g., von Aufschnaiter & Rogge, 2010). Also, at the end of the sequence (Figure 3), he creates a cross-reference to the main idea of the lesson "Forces can make objects move or change their shape."

Is energy the same as force		**IIIb**
Both words can be used for the same thing	45 sec	II/IIIa
Power plants generate [what we call] energy		IIIa
Why do you have to eat rolls and jam for breakfast	20 sec	**II/IIIb**
Why do we have to eat anyway	20 sec	**IIIb**
We have to eat in order to be able to do something		IIIa
Why does a patient need food	15 sec	**IIIb**
He needs energy for his power of resistance		II/IIIa
What does the body do with the energy while sleeping		**IIIb**
We say energy is consumed/dissembled	15 sec	II/IIIa
Energy is needed for the circulatory system		II/IIIa
How is energy consumed		**IIIb**
Somehow sugar emerges	15 sec	II
The patient has to breathe		I/II
All humans are crossbreeds	5 sec	**IIIa**
What we take in is energy	55 sec	**IIIb**
Taking in energy does not give force		**IIIb**
If we do something, we get rid of the energy		**IIIa/IIIb**
Everybody knows that we loose power while making sports		**II/IIIa**
What is lacking then: force or energy		**IIIb**
What does match better		**II/IIIb**
We don't have energy any more		I/II
Energy is the ability to do something, force emerges if one is doing it	15 sec	**IIIb**

Figure 2. TB's section on energy. All lines of thought, for both, teacher (bold) and students are presented as well as the assigned levels for conceptual qualities. Two levels are given whenever the assignment is not clear from what the person says or does. Horizontal lines indicate coherent lines of thoughts, a "sequence", and how long the sequence takes.

Is solar force energy [word association]	II
[...]	
Does solar force belong to physics forces	**II/IIIa**
..?..	
I agree, the solar force comes from the sun	**II**
Where do we have to assign it	**II**
Solar force has to do with current [word association]	II
Current circulates	**IIIb**
This belongs to movement	**IIIa**
Forces can make objects move or change their shape	**IIIa**

Figure 3. TS' sequence on energy. All lines of thought, for both, teacher (bold) and students are presented as well as the assigned levels for conceptual qualities. Two levels are given whenever the assignment is not clear from what the person says or does. The whole duration is 40 seconds.

The analyses of TB's and TS' lesson reveal differences between the two teachers which are summarized in Table 2. TB's lesson seems to be more "dense" as it establishes more lines of thought, refers to more different content elements and uses more sequences all of which with shorter duration. Furthermore, the more general topics of the lesson (described with sections) change more quickly than for TS. From the knowledge we have about student learning (e.g., von Aufschnaiter & Rogge, 2010) the analyses clearly demonstrate that TB's ideas were more often too abstract, presented too fast and included too many different contents and not enough repetition in order to establish specific concepts. Therefore, we may be able to explain why TS' class seems to learn more than TB's class. However, why in both classes interests decrease, and this much more in TS' class, cannot be concluded from the data.

Table 2

Summary of distribution of content over TB's and TS' lessons (sequence: coherent lines of thought; Sections: coherent sequences)

Activity	**TB**	**TS**
Total time of teaching activity (values rounded)	44:30 minutes	46:30 minutes
Number of the teacher's lines of thought	159	98
Approximate number of different content elements developed	27	16
Number of sequences developed	70	34
Mean duration of sequences (values rounded)	40 seconds	80 seconds
Number of sections developed	8	6
Mean duration of sections (values rounded)	5:30 minutes	7:50 minutes

CONCLUSIONS

Current research on classroom activities typically reveals teaching patterns and relates those to student outcomes in order to identify those patterns that seem to be more effective than others. Also, it helps to identify teacher profession. This is the kind of information we currently get from video-based classroom research. However, criteria derived from such kind of research about good instruction are often vague and only loosely related to students' learning pathways. What exactly makes an instruction "clear", "structured" or "activating"? This is the kind of information that typically misses in research on classroom activities. Thus, this paper claims that we need to develop (from research on students' learning processes) criteria which can be used for both a description of teacher *and* student activities in order to relate these together. This information would help to understand better, which kind of instruction is successful (and when) during students' learning processes. This is a different perspective than, much more globally, investigating effectiveness of whole teaching units. There, it is not possible to determine exactly what has caused the "effectiveness". Especially, those measures often lack a focus on *content* (such as the complexity of an explanation which is probably very important for students' understanding). In order to include students' activities in more detail into classroom-based research, classroom videos need to focus not only on the teacher but also on how students respond to instruction. However, it is not likely that all students can be traced in detail. From our research, I would recommend to investigate two to three groups with two to four students each (more information in v. Aufschnaiter & Rogge, 2010). These students can either be chosen randomly or by specific pre-test results (for instance, one group with high and one with low prior knowledge and/or interest).

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LEARNING ABOUT GREENHOUSE EFFECT: FRAMING THERMAL PHENOMENA AND OPTICS IN A CHALLENGING CONTEXT

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Abstract: We developed a cycle of design, implementation, evaluation and redesign of a teaching learning sequence on the thermal effects of interaction between radiation and matter, infrared emission of bodies, greenhouse effect and global warming. Six high school classes (for a total of 121 students) have been involved in the experimentation of the sequence. The first implementation showed how the introduction of a complex issue requires a progressive conceptual construction and led us to point out a sequence of five cognitive steps necessary to attain a coherent explanation of the greenhouse effect. The accomplishment of these steps entails re-structuring the teaching of thermal phenomena and optics, and discussing the energy balances in stationary conditions of a system exposed to a constant source of energy.

The obtained successes and failures and the analysis of the students' learning progression provided relevant information for challenging the persistent obstacles and misunderstandings. This led to a new cycle of design and implementation of the sequence, involving: the introduction of some activities concerning the teaching of basic energy concepts and thermal phenomena; the production of materials for students aimed at helping them both in classroom activities and in a deeper reflection on the topic; the elaboration of a teacher guide explicating the criteria of the proposed path. The experience confirms the usefulness of significant driving issues as centres of interest promoting the learning of scientific concepts and models, and the need of an iterative cycle of design and implementation of the teaching learning paths in order to take into account effects and elements that only a contextualised practice can reveal.

1. Background, Framework, and Purpose

Our research concerns a cycle of design, implementation, evaluation and redesign of a teaching learning sequence on the thermal effects of interaction between radiation and matter, infrared emission of bodies, greenhouse effect and global warming. This work started in the framework of a European Comenius project aimed to construct a teaching learning sequence focussing on a socially relevant driving issue, the anomalous greenhouse effect and global warming, and continued within a Project funded by the Regional Office of the Italian Ministry of Education aimed at introducing innovative contents and methods in the High School Physics curriculum, which involved six experienced high school teachers. The design of the sequence (described in Besson et al. 2010a) was based on our “three-dimensional approach”, involving a synergic integration of a critical analysis of the scientific content in view of its reconstruction for teaching, an overview of current proposals (textbooks, common teaching), and an analysis of didactic research on the topic (Besson et al. 2010b). The implementation of the sequence in different high school classes and in university courses showed how the introduction of a complex issue in the curriculum makes it evident the necessity of revising the traditional ways of teaching the connected basic subjects (in our case thermal phenomena and optics) and requires a progressive conceptual construction taking into account specific students' needs. Based on these results, we started a new phase of our research aimed to:

- analyse the students' learning process, their cognitive paths, acquisitions and obstacles during the sequence and retained knowledge after the sequence;
- restructure the didactical organisation of the contents and prepare new materials for students in order to overcome the problems evidenced during the previous experimentation.

2. Students' conceptions on the topic

Few researches have been carried out about students' ideas on thermal effects of radiation and the existing ones are focalised on particular aspects:

- effects of radioactivity on living organisms (Rego & Peralta 2006, Lijnse et al 1990, Millar 1994);
- interaction between radiation and metals involving quantum atomic models (Redfors 2001).
- the greenhouse effect and global warming (Boyes et al 1993, Rye et al 1997, Groves & Pugh 1999, Koulaidis & Christidou 1999, Anderson & Wallin 2000, Österlind 2005, Lester et al 2006, Kilinç et al 2008).

It was found, for example, that many students consider:

- the ozone layer depletion and radioactivity as causes of global warming and the skin cancer as an effect;
- the idea of 'trapping' of sun rays by the atmosphere as explanation of the greenhouse effect.

Some researchers also developed ideas and approaches for dealing with these misconceptions on greenhouse effect and global warming (Meadows and Wiesenmayer 1999, Österlind 2005, Lester et al. 2006), but specific studies on student conceptions and teaching proposals for secondary school about radiation-matter interaction are still lacking. In our research we focused on some aspects of the problem (Besson et al. 2010a). For example, we have found:

- a tendency to give absolute meaning to optical properties (transparency, absorptivity, emissivity) as intrinsic characteristics of bodies or materials;
- a lacking or incorrect consideration of infrared emission in thermal balances;
- a confusion between transitory phases and steady state situations;
- a difficulty in considering the interrelation of multiple factors and phenomena implied in energy balances.

3. Rationale

The experimentation of the teaching learning sequence with small groups of students (both in university and in high school) led us to specify a sequence of cognitive steps toward the construction of a coherent explanation of the greenhouse effect:

a) to recognize and explain a stationary condition of temperature for objects exposed to sun or lamp radiation;
b) to differentiate heat and radiation and realize that objects emit thermal radiation;
c) to differentiate visible and infrared radiation and the behaviour of a material for visible and far infrared (glass is transparent to visible but absorbs IR thermal radiation);
d) to put together the knowledge acquired in order to understand the radiative greenhouse effect in a box-model;
e) to understand the greenhouse effect on the Earth and global warming.

In the following we summarize the main features and the contents of the teaching sequence.

a) *To recognize a stationary condition of temperature for objects exposed to sun…*

The thermal effects occurring in an object exposed to solar radiation are studied by means of outdoor experiences. Small metal cylinders of equal masses having white, black and polished surfaces and a transparent cylinder are exposed to solar or lamp light. A temperature sensor is inserted in a little hole in each cylinder; while another sensor measures the ambient temperature. Graphs of temperature versus time for each cylinder are obtained with hand-held data loggers showing the process towards the stationary temperature condition.

b) *To differentiate heat and radiation and recognize that objects emit thermal radiation*
By means of an infrared (IR) radiometer students verify if a body, at a given temperature, emits radiation. The power of the IR radiation emitted by bodies at different temperatures is measured (temperatures under the ambient temperature are also considered). A rapid increase of the emitted radiation power with the temperature is verified. The objects included stones, tree trunks, metals, grass and leaves; some of them should be in the sun and others in shade. Measurements are repeated after having inserted a layer of 'clear' glass or plastic between the objects and the radiation sensor. One observes that the intensity measured by the sensor drastically decreases. This shows that most of the radiation emitted by the considered objects does not pass through the glass (plastic). Then, the word *clear*, used in everyday language for glass and plastic, refers only to visible light.

c) *To differentiate visible and infrared radiation and the behaviour of a material…*
Laboratory activities are performed and discussed with the students to point out that:
– the emission spectrum of a source depends on the temperature (at temperature near to room temperature the emitted radiation is in the far-infrared region);
– optical properties of materials depend on the considered region of the spectrum (on the frequency or wavelength of the radiation);
– some materials are transparent to visible light but absorb far-infrared radiation.
Aiming at *seeing the invisible*, simple observations are performed using a digital camera having infrared sensibility. The spectrum of the lamp of an overhead projector is produced on a white wall by using a transparent prism and students can observe through the camera the presence of IR radiation beyond the red colour. Moreover, the IR radiation emitted by a remote control can be photographed to show that radiation is emitted, and the black 'opaque' plastic that covers the remote control is transparent to this radiation while it is opaque to visible radiation (figure 1).

Fig. 1. "Seeing" through a camera IR radiation emitted by a remote control

d) *The radiative greenhouse effect in a box-model*
The behaviour of a small greenhouse under solar radiation is studied in an outdoor activity. A black aluminium plate is placed at the bottom of a plastic box and it is exposed to solar radiation. The temperature of the plate is measured by means of a temperature sensor until the temperature becomes stationary. Then the box is placed in the shadow and the temperature in the cooling phase is measured.

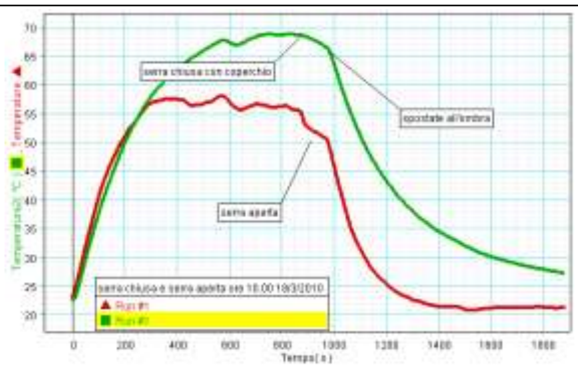

Fig. 2. Examples of temperature versus time graph for the metal plate in the box without and with the lid on.

The same measurements are repeated with a clear glass (or plastic) lid on the top of the box (in this way a small *greenhouse* is created). Before carrying out the experiments, the students are asked to predict and to draw graphs of the temperature of the plate versus time in the two cases. In figure 2 examples of experimental graphs are shown:
An interpretation of the experimental results is discussed with the students by using a model of the energy fluxes (in and out) according to the scheme shown in figure 3.

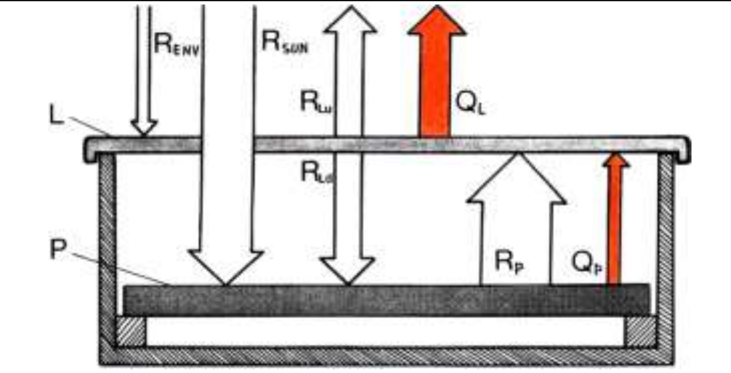

Fig. 3 Radiation and heat fluxes in a small greenhouse box.

e) *To understand the greenhouse effect on the Earth and the global warming*
The model of energy fluxes developed for the greenhouse box can be the starting point to understand the physical aspects of the Earth greenhouse effect. The planet's surface plays the same role as the black plate; the atmosphere plays the role of the glass lid: it is transparent to most of the solar radiation, but absorbs most of the far-infrared radiation emitted by the Earth's surface. This absorption is due primarily to water vapour, clouds and CO_2, with a smaller 5% contribution from the gases O_3, N_2O and CH_4 and a minor contribution of other anthropogenic gases, such as the chlorofluorocarbons. Infrared radiation is emitted by these gases and by air towards the Earth and towards outer space. This dynamics produces a stationary temperature on the surface of the Earth compatible with life. However, an increase of the green house gases concentration makes the energy budget of the system Hearth-atmosphere vary, and as a consequence produces a re-adjustment of the equilibrium temperature in order to restore the energy balance.

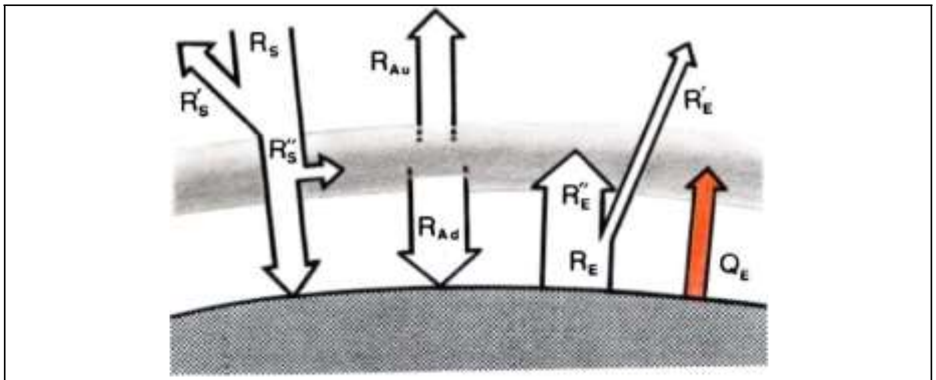

Fig. 4. Modelling radiation and heat fluxes in the *Earth–atmosphere* system

4. Organization of the work and data collection

Six high school classes experimented the sequence, four with 17-18 years old students (group A) and two with 15-16 years old students (group B), for a total of 121 students. Data collection was carried out by means of different tools: an initial and a final questionnaire; work sheets filled in by the students during the experimental activity; video and audio taping of the class activities; teachers' reports on the class work collected in log books. All documents have been discussed in periodical meetings and uploaded in a web site devoted to the project. Teachers prepared a final report where they described which elements of the proposed sequence they considered essential, how they passed from the research plan to their individual teaching plan and to the actual activity in classroom, and the results they observed at the end of the sequence. After having taught the sequence, the teachers continued to work with us to restructure the teaching of thermal phenomena in their classes, to elaborate new materials for students and to prepare new teaching plans for the modified sequence.

5. Results of the first implementation of the sequence

The analysis of the pre- and post- tests has shown clearly an increase in the consideration of the role of radiation in thermal processes (74% vs. 17%), in the awareness of the existence of a stationary temperature (100% vs. 67%) and of the related energy balance (44% vs. 10%,). Nevertheless, this last result is not satisfactory. In fact, the idea of 'saturation' strongly persists (50% vs. 57%): according to this idea materials have their own maximum possible temperature that once it is reached necessarily cannot increase yet. This fact can be interpreted as due to the slowness of the process needed to pass from explanations in terms of object properties to reasoning in terms of interactions and balances.
Concerning the greenhouse effect, data show a strong decrease of explanations based only on thermal isolation (11% vs. 39%) and an increase of correct reasoning (19% vs. 9%, and 26% vs. 12% for group A only) or almost correct, i.e. at least differentiating phenomena of absorption and emission of visible and infrared radiation (18% vs. 4%, and 29% vs. 5% for group A). Nevertheless, the idea of 'trapping' of sun rays strongly persists (43%, and 32% for group A), and the dependence of transmission and absorption on the region of the spectrum is evoked only by 32% of all students and by 45% of group A, vs. 10% and 15% respectively in the pre-test. For comparison, we found that among 51 graduated student teachers only 6% give a correct explanation, 35% express the idea of trapping of sun rays and 31% sustain that sun radiation enters and heats but heat cannot get out or can get out partially by conduction and convection.

6. A new cycle of design and implementation

These results, good but not optimal, confirmed the difficulty of the topic and suggested some improvements of the sequence. Teachers observed that some students' difficulties could be caused by an incorrect or insufficient understanding of basic topics concerning energy concepts and thermal phenomena. Students' reasoning is strongly influenced by the first presentation of the topic (examples, descriptions, explanations...) since they tend to reuse the same initial patterns of reasoning, even if not appropriate, for the new situation. We call this tendency, observed also in other topics, the "imprinting" phenomenon in science learning (resuming the term introduced by K. Lorenz). To avoid this negative effect, it is useful to present since the beginning a wide panorama of different situations and factors, in a qualitative and simplified manner, in order to make it easier for students form an idea not limited on a particular case or aspect. For example, in introducing thermal phenomena it is better to present from the onset many different ways for changing the temperature of a body and also consider stationary situations without thermal equilibrium (in usual simple cases such as a room where the heating is on but the temperature is constant).To interpret stationary conditions, drawings, schemata and data representing energy fluxes can be used.
Based on these results, we started a new phase of research aimed to:

- Revise some aspects of the sequence, particularly the way of teaching basic energy concepts and thermal phenomena;

- prepare new materials for students in order to overcome the problems identified during the previous experimentation.

We introduced a new phase at the beginning of the sequence aimed at stressing the distinction between the quantities temperature, energy, heat and work while dealing with thermal phenomena. We suggest to consider with students different way to increase the body temperature (mechanical work, friction, heat, chemical reactions, lamp and microwaves radiation), and to show that it is possible to heat bodies without giving heat and to give heat without heating. We prepared, together with the teachers, three types of material: sheets for experiments; booklets for students' personal study and deepening of the treated topics; suggestions for teachers. Experiments are considered part of the scientific discourse on the topic, in a dialogue between theory, hypothesis and experiments. The booklets are not designed as handbook chapters, they want to be adherent to the experimental activities, resuming their particular aspects, by taking into account also what students have observed. The path is divided in three parts in order to facilitate its insertion in the usual curriculum: T (thermal phenomena), R (radiation), S (greenhouse effect). Moreover, we developed an introductory phase O to supply the knowledge on optics and waves necessary for the other phases.

We used these materials in four high school classes. The evaluation is still in progress. We noted that knowledge of basic energy concepts is necessary for understanding greenhouse effect, but also vice versa the study of greenhouse effect can be a useful *driving issue* for introducing basic energy concepts and phenomena. The experience has shown that it is important to overcome a too de-contextualized and technical approach to physics teaching. Using specific *driving issues* as foci of interest can promote the progressive construction of physics concepts and models. In particular, this topic (greenhouse effect and global warming or climate change) together with its intrinsic general interest (see IPCC 2007):

- offers an opportunity to clarify the distinction between work, heat, temperature, internal energy, radiation energy, concepts often confused by students, and to introduce schemes for representing energy fluxes and balances.
- focuses on the importance of reasoning in terms of energy balances to analyse stationary situations without thermal equilibrium. Situations of this kind intervene in various physics phenomena and are difficult to understand for students who often confuse transitory phases and steady state conditions.

7. Conclusions and Implications

Results confirm the importance of passing through all the cognitive steps mentioned in section 3. Presenting the entire explanation of the greenhouse effect in a unique step is not effective; the phenomenon is complex and needs a progressive rapprochement.

Students' reasoning is strongly influenced by the presentation they previously received of thermal phenomena and optics because they tend to reuse the same initial pattern for new situations even if not appropriate. To avoid this "imprinting" effect it is useful to present since the beginning a wide panorama of different situations, for example, to consider both situations of thermal equilibrium and non-equilibrium stationary situations, in familiar simple cases.

The successes and failures obtained in the class work and the analysis of the students' learning progression provided relevant inputs for challenging the persistent obstacles and misunderstandings and for revising some aspects of the TLS, in particular the presentation of basic concepts on thermal phenomena, including the stationary temperature situations in presence of radiation sources. Thus, a new cycle of implementation, analysis and refinement was activated in order to take into account effects and elements that only a contextualised practice could reveal (Design-based Research Collective 2003). To this purpose, we revised some aspects of the sequence, concerning the way of teaching basic energy concepts and thermal phenomena and we prepared new materials for students in order to overcome the problems identified during the previous experimentation and facilitate students' understanding.

A comparison between previous results and the new ones will help us to achieve a more precise picture of what elements can contribute to make it possible and profitable introducing a complex and challenging theme such as the anomalous greenhouse effect and global warming in the physics curriculum in high school.

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Which Standards should Textbooks Meet to Support Competence Oriented Teaching?

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Abstract: Textbooks are claimed to be one of the most important tools in the implementation of new school curricula. As there has hardly been done any research in the field of textbooks in German-speaking countries, our project focuses on the following question: Which standards should science textbooks meet in order to support competence oriented teaching in secondary schools?
To answer this question, a qualitative survey has been performed with 40 experts. This resulted in a checklist for teaching materials consisting of thirteen categories with 148 standards for teaching materials. These standards may support authors generating teaching materials as well as committees to enact newly published teaching materials. To make the assessment tool even more precise, it is planned to perform a quantitative survey with about 250 experts weighing the relevance of each standard.

Keywords: Textbook, teaching material, competence oriented teaching, science, secondary school

Background, Framework and Purpose

The role of textbooks and other teaching materials in science education is still significant. Why? Textbooks are the “resources most consistently used by teachers and their students in the course of the joint work."(Valverde, Bianchi, Wolfe, Schmidt, & Hounang, 2002, p. VIII). Despite this significance, there are hardly any ongoing studies in the field of textbook research in German speaking countries (Oelkers & Reusser, 2008).This can be illustrated by the fact that the newest empirically evaluated manuals for textbook analysis in German speaking countries were generated over 20 years ago. The two most famous ones are the “Reutlinger Raster [Manual]” (Rauch & Tomaschevski 1986, translated into English Rauch & Tomascheski, 1995) and the “Bielefelder Raster [Manual]” (Laubig et al. 1986). As a consequence, there are no research based standards available neither to write nor to legitimatize modern and competence oriented science textbooks and other teaching materials. To reduce this “research gap”, our project aims to setup empirically evaluated standards for science textbooks and teaching materials for secondary schools taking the upcoming competence and context oriented teaching approach into account.

Theoretical Framework and Research Question

The unsatisfactory results of the PISA and TIMSS studies have induced a reassessment of the Swiss school curriculum, especially in science. In order to implement the upcoming reform successfully, developmental work has to be performed not only on the assessment level but also on the micro-level of teaching (day-to-day management) (Gräsel & Parchmann, 2004). How can this be done? Valverde et al. (2002) mention that textbooks could support the

implementation on the micro-level as they “are commonly charged precisely with the role of translating policy into pedagogy. They represent an interpretation of policy in terms of concrete actions of teaching and learning." (p. VIII). This is supported by a survey in which persons who set up the curriculum mentioned that the curriculum influences to 64% the setting up of new textbooks and teaching materials (Bähr & Künzli, 1999).
Moreover, results from TIMSS attribute textbooks a strong influence on the test performance of students and hence affirm the crucial significance of textbooks (Valverde et al., 2002). Assuming that authorized textbooks for the new curriculum are lacking, teachers necessarily depend on their own idea of learning (Oelkers & Reusser, 2008). And given the fact that there is hardly any current empirical study in the field of textbook research in German-speaking countries (Oelkers & Reusser, 2008), our project is going to make a contribution to textbook research by answering the following question: Which standards should science textbooks meet in order to support competence oriented teaching in secondary schools?

Research Design and Methodology

A triangulation of methods is used to generate the standards for science textbooks and other teaching materials empirically. In the following section, the different methodological parts are described. For an overview see (Fig. 1).
After a pilot study, nine open questions were generated asking about different aspects of science teaching materials supporting competence oriented teaching. With a return run of 68%, 40 experts from three German-speaking countries answered the open questions. Experts were: authors, science educators, educationalists, publishers and science teachers with high professional competences. The answers of the experts were analyzed by the summarizing qualitative content analysis described by Mayring (2010).

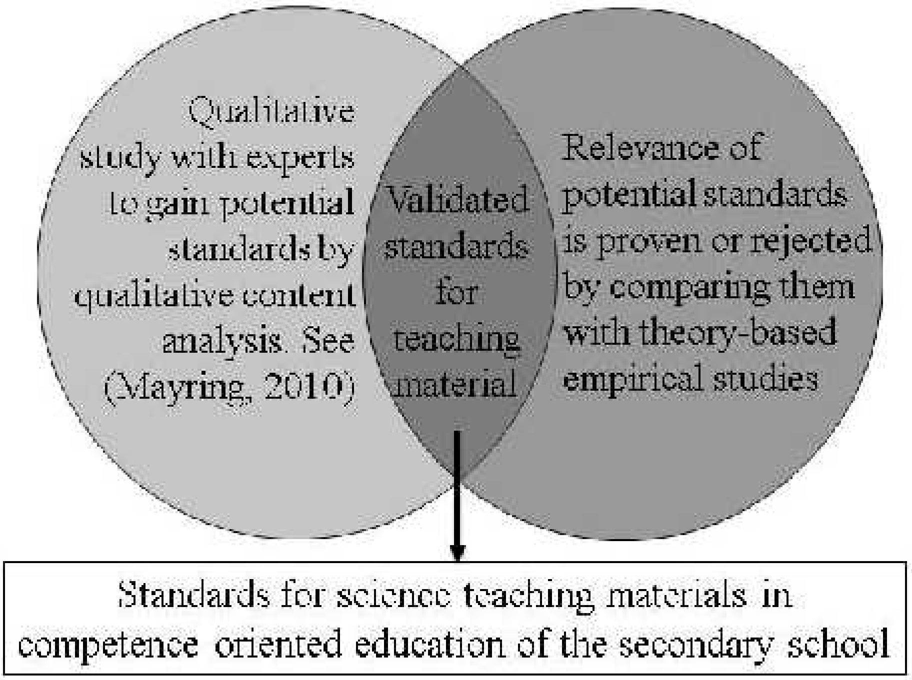

Figure 1: Methodological concept to obtain standards for teaching materials.

The potential standards obtained by the qualitative survey were checked for consistency by analyzing theory-based empirical studies (Fig. 1). This means that the standards were only

approved, if at least one theory-based empirical study in the field of science didactics, didactics and educational science supported the content of the standard.
For classifying the standards into categories, 23 existing "manuals for teaching materials" were scanned for interferences. In total, the following four classes were found (Table 1):
- Class 1: "The standards for teaching materials in general concern…" containing three categories.
- Class 2: "The standards for teaching materials taking competence oriented teaching into account, concern…" containing six categories.
- Class 3: "The standards for teaching materials focusing on the teacher's support, concern…" containing two categories.
- Class 4: "The standards for teaching materials focusing on the student's support, concern…" containing two categories.

In total, 13 categories were distinguished from one another (Table 1).

Results

By analyzing the answers of the experts and validating them with empirical studies, 148 standards were found. 16 standards in class 1, 83 standards in class 2, 24 standards in class 3 and 25 standards in class 4. For details see (Table 1).

Table 1: Theory-based classes and categories for classifying the standards

Classes and Categories	Standards
Class 1: The standards for teaching materials in general concern…	
…the fit to the own institution	4
…the fit to the curriculum	2
…the quality in general	10
Class 2: The standards for teaching materials taking competence oriented teaching into account, concern…	
…the scientific content knowledge	16
…the scientific skills	15
…the exercises and assignments	5
…the experiments	15
…the media	10
…the different parts of teaching materials	22
Class 3: The standards for teaching materials focusing on the teacher's support, concern…	
…the support of teachers for teaching	19
…the support of teachers for assessing the students	5
Class 4: The standards for teaching materials focusing on the student's support, concern…	
…the support of students to learn the content and skills	11
…the support of students with different proficiency levels	14
Total of standards	**148**

In the following, the formation of one standard is shown as a representative for all standards. This example belongs to class 2 "The standards for teaching materials taking competence oriented teaching into account, concern…" and the category "experiments" (Fig. 2).

Example of a standard in class 2 and the category: "experiments"
1) Standard uttered by an expert: Experiments which can be performed by the pupils in a self-regulated way are important.
2) Confirmation of the importance of the standard by theory-based empirical studies: First empirical study "In the view of the teachers, the main benefit of the jointly developed lesson plan was the … intense, self-

regulated, content-focused engagement of the students with theoretical topics from chemistry within a lab environment." (Witteck, Most, Kienast, & Eilks, 2007, p. 116). Second empirical study "The students mentioned that they had the feeling to have worked very intensely and to have learned a lot (item 3 and 5). The structure was considered very motivating and attractive (item 13). The positive consideration was based on two aspects. One is the cooperative learning atmosphere (items 4, 6, and 8), and the other was the highly self-directed activity (items 1 and 9), and especially the chance for self-regulated lab-work activities without being given a cook-book recipe that got the highest support (item 11 and 12)." (Witteck et al., 2007, p. 118).
3) Validated standard in the manual for evaluating competence oriented textbooks: Experiments to be performed in a self-regulated way are included in the observed teaching materials. Yes ☐ No ☐

Figure 2: Example of the genesis of a standard for teaching materials supporting scientific competence oriented teaching.

Conclusion and Implications

By triangulating the expert knowledge with theory-based empirical studies, 148 standards for teaching materials have been generated empirically. By comparing this manual with the most cited research-based checklists for teaching materials in the German speaking countries, which were both generated over 20 years ago, the "Reutlinger Raster" (Rauch & Tomaschewski, 1986) and the "Bielefelder Raster" (Laubig, Peters, & Weinbrenner, 1986), it can be shown that many things have changed. This means, that the change in the school system as well as the new media legitimates the research done for developing the new manual. In addition to the clear focus on competence oriented teaching, the new "manual for evaluating competence oriented textbooks" is to our knowledge the first research-based manual for competence oriented teaching. Moreover, the manual can be both used for authors as a research based scaffold to generating teaching materials and for committees to having a research based tool to enact new textbooks. To make this latter assessment tool even more precise, it is planned to perform a quantitative survey with about 250 experts weighing the relevance of the single standards.
Additionally, another study of our research team focuses on the use of current textbooks. Remembering the complaint of Oelkers and Reusser (2008) about the lack of current studies in the field of textbook research, these studies diminish this lament at least to a certain extent.

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STUDY OF THE APPROACH OF ELECTRICAL CONCEPTS IN TEACHING PHYSICS AT COLLEGE (PROPOSALS FOR THE SYRIAN EDUCATIONAL SYSTEM COMPARED WITH THE FRENCH SYSTEM)

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Abstract: As in all over the world, the Syrian educational system is influenced by social and cultural factors. Nowadays, a cultural movement has been established in Syria, which aims to improve this educational system.
In the context of a cultural exchange agreement between Syria and France, I was selected with others to come to France in order to obtain a PhD in physics Education which aims to construct useful suggestions to the Syrian system in comparison with the French system, to participate in the actual development of educational system in my country (Syria).
The motives of my research are to participate in this cultural movement in my country and to help improving as good as the methods teaching physics compared with another educational system which is the French system.
Therefore my thesis aims to suggest proposals of an appropriate curriculum in the Syrian context, these proposals will be based on the choice of scientific and social values presented explicitly in the "Syrian National scholar standards" as knowledge to be taught, taking into account the consideration of the essential role of teachers.
Today, Electricity has a major role in economical, scientific, technical field, in social practices and everyday life. Therefore, electricity has always been an important subject in the teaching of physics. So I chose to work on an introduction to electrical concepts (voltage, current, resistance ...) in college in Syria and also in France.

Keywords: Electricity, Curriculum, Syria, Teacher"s training, Students" learning success

INTRODUCTION

Recently, social, economic and environmental concerns have led many countries to develop new educational programs to face up to the enormous technical and economic development. According to a pragmatic approach, as societies are increasingly influenced by the ideas and products of sciences and technologies, all citizens in the future will be able to confront the problems if they have the base in scientific knowledge.

We aim, not only to allow students developing their scientific and technological knowledge, but also developing their roles in the modern society.

In this work, I introduce a contribution to the Syrian education system that improves the educational knowledge of students to enable them to understand and participate in the discussions of the modern societies.
I focus my work on the essential role of physics teachers training as major actors in this renovation, and also on the students‟ representations and conceptions as recipients of this renovation.

Theoretical framework

The theoretical framework of my thesis is based on a curricular approach of electrical concepts in teaching physics in college.
I start my research from the Syrian official documents (the curriculum and textbooks of physics in college). My objective is to concentrate on what already exists in these documents and to analyze the method in which we provide the physics in college. In particular how to present electricity and to search how we introduce the electrical concepts in college in Syria (place of experience, the model and modeling…).
Indeed, in Syria, we teach electricity by an electrostatic approach, we start by teaching the concepts of charges and electric fields. In dissimilarity, France has opted for an approach electrokinetic in teaching the concepts of short circuit and electrical current starting it from the fifth class.
The difficulties in learning electricity have been noticed for the Syrian students according to Syrian teachers. Also the Syrian educational program notes an immediate need to change their current mode of approach to introduce electricity in Syrian textbooks.
Thus, in my investigation, I opted for a comparative study between the Syrian and French educational systems; I rely on an approach of the process of didactic transposition, which is a complementary idea in a curriculum approach.
I found in my historical and epistemological study that there are several approaches to introduce the reference‟s knowledge.
Depending on the results of this study, I note the existence of three modes of approach in presenting the electrical concepts which I have found in international examples.
We can present the electrical concepts with a theoretical and mathematical method (Electricity and magnetism, Berkeley, 1965), or with a more concrete and real presentation of the electricity, called phenomenological way (the Feynman physics courses: Electromagnetism 1. Edition Wiley, 1979), or we can choose to provide the electricity in a more modern way, that is the phenomenotechical way (Bloomfiels, 2006).
In the new Syrian programs of 2005, I found that they focused on the role of students, and on the positive role that allows them to participate in the learning‟s operation, so they will not be a negative „‟Recipient‟‟‟.
As part of this curricular approach, and based on the researches of Closset JL (1983), J.Toussaint (2006), and Calmettes B. (1996), I will apply the idea of the “Curricular Martix”‟‟ (such as Kuhn T. identified in his article cited in the research paper of Jacques Toussaint‟ HDR) in teaching electricity in the Syrian context.

THE RESEARCH QUESTIONS

The overall objective of my research is to give useful proposals for the presentation of concepts in the electric field of physics learning in college in Syria. The purpose is to provide methodological tools that are likely to be valuable and effective in teaching electricity.
I will try in this work to find answers of the following question:

What proposals can be done to improve the Syrian educational system in comparison with the French system?
Based on the theoretical framework of this research, I will answer these three key questions:

- What are the respective characteristics of curricular approaches of the arrangement of electric concepts at school? What are the differences between these approaches? What choice of social and scientific values has been done to teach electricity?
- What training do we give to future physics teachers to teach electricity in college?
- What is the role that we must give to students in their learning?

METHODOLOGY AND DATA COLLECTION

I had in my Master‟s research paper, executed a historical study of the development of electricity in history (electrostatic, electrocinetics) since the first studies of Franklin up to now.
This study was followed by a study of the different approach to expose the electricity at the university level.
Then, during my first year as a PHD student, I executed a pre-analysis study of the contents of physics in college (programs, textbooks, accompanying documents, teachers guiding books….) in order to compare the method of introducing electrical concepts in the Syrian and French curriculum. The content analysis was effectuated according to the reproducibility rules and instructions and exchange between researchers and therefore a „‟quasi" objectivity.

a. The reporting contents

Based on the results of the previous historical and epistemological analysis, considering the three approaches of introducing electricity in the reference‟s knowledge (Mathematical approach, Phenomenological approach, and Phenomeno-technical approach), and to answer the research question and to realize our curricular study of electrical concepts, my research s‟ methodology is developed in three main axes:
In Syria, there is only one official textbook dedicated to each level of education. While in France, many textbook are available to teachers and students. So I have chosen three different editions of French textbooks that are commonly used in French schools (Micro-Mega, Hachette, Hatier).
I have chose the standard of analysis in order to compare the textbook in both Syria and France in terms of teaching the electrical concepts.
Thus, I have relied on the theoretical framework of my thesis with the three previous ideas by a process of didactic transposition (Y. Chevallard). I have tried to find a relationship between the three levels of knowledge (reference‟s knowledge, knowledge to be teach, taught knowledge) (Y. Chevallard, 1991).

b. The actors of the renovation : the teachers

In a second step, I complete this curricular study depending on the results of the previous analysis of the contents by focusing on physics teachers‟ training to define their conception in electricity through a questionnaire addressed to the college physics teachers in Syrian and France.
This questionnaire will be followed by audio interviews with the same teachers, asking them questions such as: what is the electricity in your opinion? What is the preferred method to teaching electricity in college?
I sent a questionnaire to physics‟ teachers in college in Syria in August 2011 and I got 24 answers.
In this questionnaire, the teachers answered scientific, methodological, and technological questions. The results are presented in the paragraph below (Results).

In France, I intend to choose for each edition of textbook 10 teachers to the questionnaire, so I will have 30 replies, and I will choose 10 teachers for the interviews, considered his experience in teaching, and the constraints that are likely to be encountered in this type of data collection. The questionnaire with French teachers will be distributed at the end 2011.

c. Recipients of the renovation: Students

The third axe of this curricular study is to analyze the mental representations of the electrical concepts for students.

I intend to distribute a questionnaire to students trying to find the difference between Syrian and French system, knowing that the introduction of electrical concepts in Syrian and French textbooks is very different from each other.

The results of these three methodological approaches will help me to identify the causes of these difficulties in learning electricity among Syrian students, and to define the type of problems (method of presentation in the programs or textebook, teaching method, social difficulties, etc). So I can at the end achieve my purpose in this research and I could thus make proposals for the teaching of electricity in my county.

PARTIAL RESULTS

Relying on our research questions, some ideas are emerging after the first experiment carried out.

a. Preliminary analysis of the Syrian and French official documents

In this preliminary analysis, I will discuss some points which I find interesting in my approach:

1. Orientation far from experimental method in the Syrian program but not in the French one (Syrian National scholar standards, 2007).
2. One textbook for each scholar level in Syria, but many in France.
3. Presentation close to the historical evolution of electrical concepts in the Syrian programs and textbooks, for example we begin our teaching of electricity in the fifth class in college with teaching the concepts of electric charges.
4. In the French side, the programs and textbooks have chosen to start teaching the concepts (simple circuit, electric current, etc.
5. In Syria, the phenomena exist in the scholar book to validate theories. In France, the situation has been addressed to find a solution.

From what I presented above, I found that there are several approaches to introduce electricity for students.

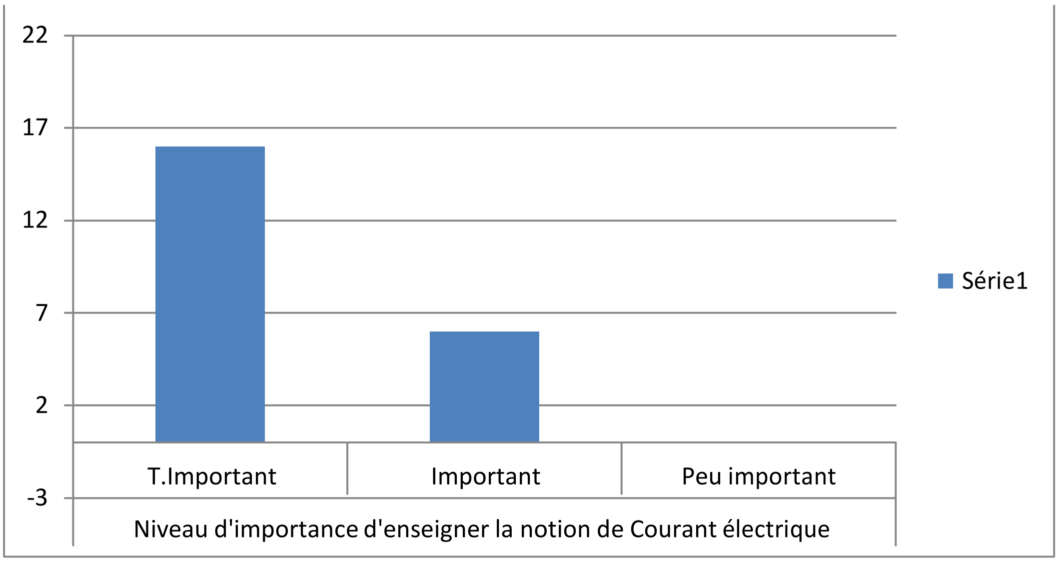
b. Analysis of the questionnaire given to physics teachers in Syria

I submitted a questionnaire to some Syrian physics teachers that are more interested points:

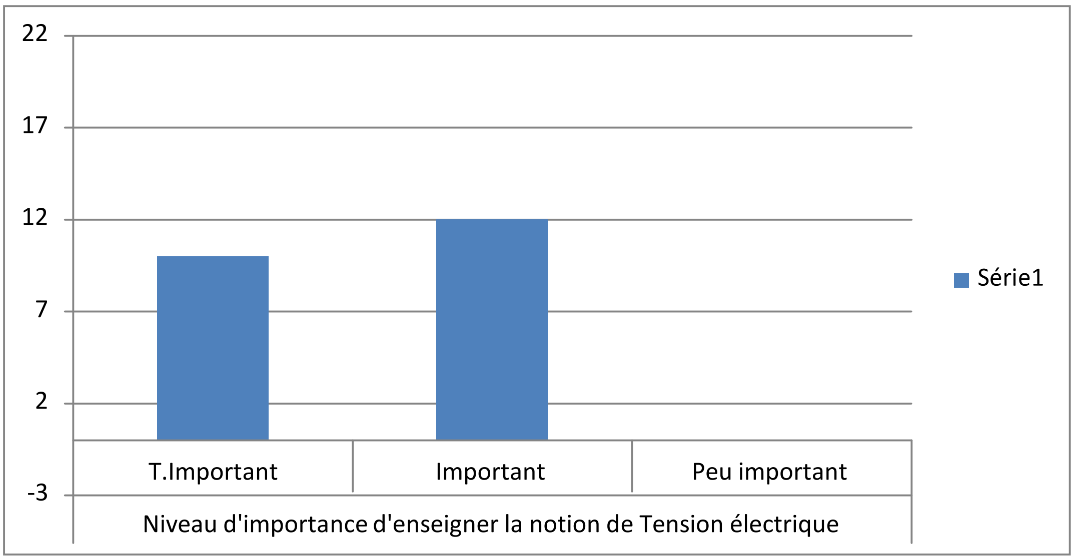
1. Concerning the answers of the question: “Have you ever had a didactic training?””: for Syrian teachers the didactic training is equal to one year pedagogical training which is proposed in the faculty of sciences education which prepare the future teachers who had the diploma in their specialties to teach in a public school.
   But the problem is that before 2005, it was not required for the competition of teaching in schools. It became obligatory in 2005. Therefore, we have identified more than 59% of the teachers interviewed had not had a didactic training, and

only teachers who had less than 5 years of experience have answered positively to this question.

2. Concerning the answer of the question: "what is electricity for you?": it was the **microscopic model** which appeared strongly in most of the answers. A **concretization** of the electrical concepts that appear in the word „"**Conductor**" that I found in several answers like this one: (Torrent of electrons path into the **conductor** in one direction).
   Also, teachers confuse the general concept of electricity with the concepts of electric current, and they forget to speak about the basic concept in electricity which is the concept of Voltage.
3. The two following histograms show that most of the Syrian teachers believe that the electric key concept is the electric current and not the Voltage.



Histogram (1) level of importance of teaching the concept of electric current in college in Syria



Histogram (1) level of importance of teaching the concept of Voltage in college in Syria

4. I found that over 50% of Syrian teachers agreed with the idea of teaching the concepts of electric current, intensity, and voltage concretely.
5. **Teachers** find **difficulties** in teaching the electricity, to overcome these difficulties and to help their students for a better learning of electricity, they proposed three ideas that seem to be useful and logical:
    a. **The experimental method** (forming un electric circuit, powering a lamp, etc).
    b. A **recourse analog** (such as the hydrolical analogy).
    c. Implement the teaching of electricity by giving **example from domestic devices, or natural phenomena**.

These results show an immediate need to develop the system applied in teachers training in Syrian universities to update their epistemological and didactical knowledge in the field of science education.

Of course, the tracks of analysis that we have mentioned above must now be studied and developed.

c. The next step will be devoted for students

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MULTI-THEORETIC APPROACHES TO UNDERSTANDING THE SCIENCE CLASSROOM

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Abstract: Multi-camera on-site video technology and post-lesson video stimulated interviews were used in a purposefully inclusive research design to generate a complex data set amenable to parallel analyses from several complementary theoretical perspectives. The symposium reports the results of parallel analyses employing positioning theory, systemic functional linguistics, distributed cognition and representational analysis of the same nine-lesson sequence in a single science classroom during the teaching of a single topic: States of Matter. Without contesting the coherence and value of a well-constructed mono-theoretic research study, the argument is made that all such studies present an inevitably partial account of a setting as complex as the science classroom: privileging some aspects and ignoring others. In this symposium, the first presentation examined the rationale for multi-theoretic research designs, highlighting the dangers of the circular amplification of those constructs pre-determined by the choice of theory and outlining the intended benefits of multi-theoretic designs that offer less partial accounts of classroom practice. The second and third presentations reported the results of analyses of the same lesson sequence on the topic "states of matter" using the analytical perspectives of positioning theory and systemic functional linguistics. The final presentation reported the comparative analysis of student learning of density over the same three lessons from distributed cognition and representational perspectives. The research design promoted a form of reciprocal interrogation, where the analyses provided insights into classroom practice and the comparison of the analyses facilitated the reflexive interrogation of the selected theories, while also optimally anticipating the subsequent synthesis of the interpretive accounts generated by each analysis of the same setting for the purpose of informing instructional advocacy.

Keywords: Classroom Research, Multi-theoretic Research Design, Science Education, Video-based Research

INTRODUCTION

As theories in the field of education continue to multiply and divide, it becomes increasingly urgent to determine how we can make use of this diversity to inform educational practice. The task of generating instructional advocacy from research findings that are grounded in different theoretical perspectives is a very challenging one, given the interdependency of theoretical choice and research findings. In carrying out classroom research, each theory affords particular analytical strategies, each focuses attention on specific aspects of the object or phenomenon under investigation but ignores other aspects. Inevitably, each should produce distinctive findings: the products of the particular analytical stance adopted. This theory-ladenness of observation has been recognized by researchers both from the field of philosophy of science and from social science (e.g. Guba & Lincoln, 1994; Kuhn, 1996), but only recently from the educational research community (e.g. Bikner-Ahsbahs & Prediger, 2006; Cobb, 2007). Tsaparlis (2001) argued that the use of various perspectives in science education, even potentially conflicting ones, could enrich our understanding of the teaching and learning of science. Clarke (2001) made a similar point in reporting a project in which a common data set drawn from eight science and mathematics lessons was subjected to analyses undertaken from ten different theoretical perspectives.

Since different research studies undertake data generation and analysis using different theories, the warrant that might be claimed for the consequent advocacy of any particular instructional action is contingent on the chosen theory/ies, among other considerations. In the research project that generated all the analyses reported in this symposium (Causal Connections in Science Classrooms – CCSC), multi-camera on-site video technology and post-lesson video stimulated interviews were used in a purposefully inclusive research design to generate a complex data source amenable to parallel analyses from several distinct theoretical perspectives (eg positioning theory, systemic functional linguistics, distributed cognition and representational analysis). The particular combination of theories was strategically constructed to provide complementarity of perspective such that each theory accorded emphasis to different features of classroom practice. Each theory, although being applied in the analysis of the same setting, offers distinctive insights reflective of the theory's foregrounded constructs.

This symposium reported the results of parallel analyses employing positioning theory, systemic functional linguistics, distributed cognition and representational analysis of the same nine-lesson sequence in a single science classroom during the teaching of a single topic. While each analysis is demonstrably valuable in itself, in combination, these results demonstrate the partiality of any single theory or theoretically-driven analysis in attempting to capture the complexity of the science classroom and the corresponding need for inclusive multi-theoretic research designs.

A LESS PARTIAL VISION: BENEFITS AND CHALLENGES IN A MULTI-THEORETIC STUDY OF ONE SCIENCE CLASSROOM[1]

A key aspiration of classroom research is the generation of empirically-grounded instructional advocacy. Since different research studies undertake data generation and analysis using different theories, the warrant that might be claimed for the consequent advocacy of any particular instructional action is contingent on the chosen theory/ies, among other considerations. In this symposium, rather than considering convergence or compatibility as the definitive result of the particular combination of theories, we focus on the compatibility of the interpretive accounts generated by their application to a common source of classroom data. In attempting to meet the challenge of providing evidence-based instructional advocacy, we address the question "under what conditions are the interpretive accounts compatible?" In this context, compatibility of the interpretive accounts would strengthen the authority of any recommendations for instructional practice arising from that research. We suggest that such compatibility must be considered as contingent on the events, objects or actions being analysed and on the specific question being addressed by the analysis. This contingent compatibility focuses our attention on the use of theories as interpretive tools.

Multi-camera on-site video technology and post-lesson video stimulated interviews were used to generate a complex data source amenable to parallel analyses from several complementary theoretical perspectives. This approach was intended to realize two very specific aims:

[1] This section summarises the first presentation by Clarke and Xu.

(i) Understand the setting: to maximize the sensitivity of the combined analyses to a wide range of classroom actions and learning outcomes, and

(ii) Understand the theory: through the combination of theoretical perspectives, examine the extent to which the results of analyses employing various theories and the theoretically-grounded explanations of these results are complementary, mutually informing, or, perhaps, incommensurable.

Science classrooms offer a rich educational environment, providing recordable instances of language use, a variety of classroom organizational groupings, varied instructional practices (demonstration, lecture, whole class discussion, and collaborative group work, both experimental and reflective), the utilization of a variety of artefacts (both physical and conceptual), the potential for ontological, epistemological, ethical and moral tensions to emerge, and, arguably, a highly diverse range of learning outcomes. It is this richness and complexity that offers the greatest potential for the interrogation of current theory and that also poses the greatest methodological challenge.

Data Source and Data Set

The focus of the parallel analyses reported in this symposium was a seventh grade science class of twenty-seven students (11 girls and 16 boys) aged between twelve and thirteen years. Data generation employed a four-camera approach (Teacher camera, two Student cameras, Whole Class camera), including onsite mixing of camera images into split-screen video records used to stimulate participant reconstructive accounts of classroom events in post-lesson student and teacher interviews (adapted from Clarke, 2006).

Figure 1a. Video material for student interview [Student camera: Teacher camera]

Figure 1b. Video material for teacher interview [Teacher camera: Whole class camera]

The video stimulus for a student interview consisted of a synchronized split-screen display of the video images generated by the teacher camera and the camera focused on that student and her nearby classmates (Figure 1a). The teacher viewed a similar composite video combining the teacher camera and whole class video images (Figure 1b)[2]. Additional data generated for each lesson consisted of copied or scanned written material (teacher planning material, student notes, textbook and worksheet pages, and test material) and observational notes made in the classroom by four researchers, three of whom were responsible for conducting the post-lesson interviews. A sequence of nine lessons was recorded, constituting the topic “States of Matter.”

Formal data generation was preceded by two ‘familiarization’ lessons, in which all aspects of the data generation process were conducted for the dual purposes of familiarizing classroom participants with data generation procedures and familiarizing the researchers with the spatial configuration of the classroom and the typical interactional patterns and movements of the participants (camera positions relative to teacher and student locations are shown in Figure 2).

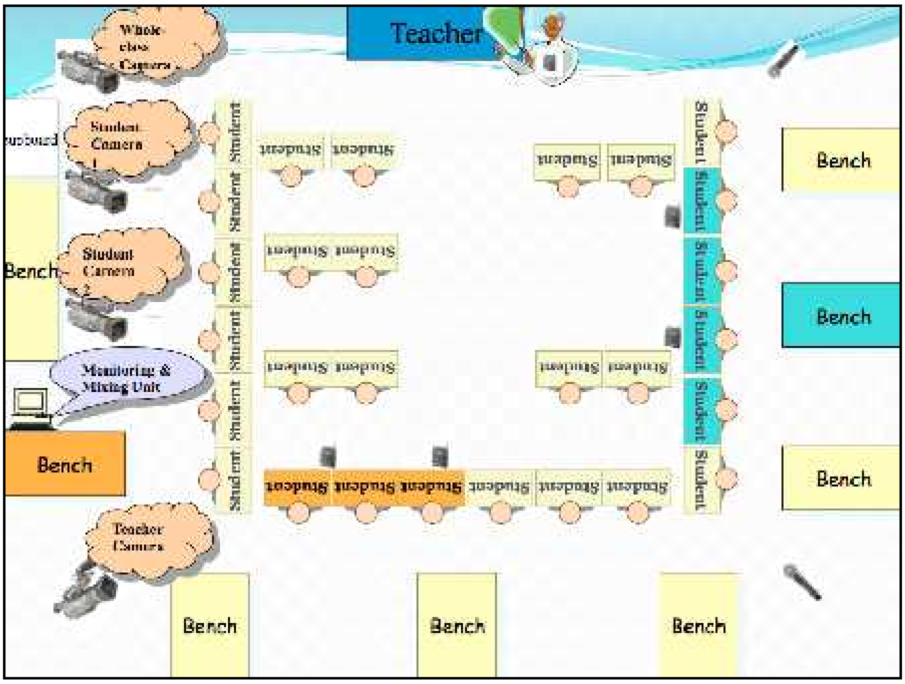


Figure 2. Classroom Layout showing camera configuration and radio microphone locations

We have an obligation as researchers to accept responsibility for the constructed nature of our data – and, of course, to document the process of data generation, identifying the points at which decisions were made regarding inclusion and exclusion. This is not always easy – particularly when the acts of exclusion are made for us by the technology, the method, or a theoretical frame that attends to some aspects of the setting and ignores others. In a multi-theoretic design such as the one employed in this project, we distinguish the “data source” constructed to anticipate and accommodate the parallel analyses from the data set reconstructed from that data source by each individual researcher for the purpose of a specific analysis.

Analysis and Synthesis in Multi-theoretic Research Designs

Each of the researchers participating in the CCSC project applied their own analytical perspective in order to select elements within the data source, thereby generating a distinct data set for each of the intended analyses. Each data set, so constructed, was then analysed using the same theoretical framework that guided the construction of the data set. In this

[2] For ethical reasons, actual images of the teacher and students cannot be shown. Images of students and teachers in both Figures 1a and 1b are simulated images developed for the purpose of illustrating the material used in the video-stimulated interviews.

respect, each analysis resembles any mono-theoretic research design in that the constructs privileged by the chosen theory were matched to data types and a research design constructed that employed methods suitable for the generation of the targeted data. Each independent analysis remained vulnerable to the same accusation of circularity or pre-determination that can be leveled at any mono-theoretic research design. Once available, however, the results of the parallel analyses can serve several purposes:

(i) By addressing different facets of the setting and thereby providing a richer, more complex, more multi-perspectival portrayal of actors and actions, situations and settings;
(ii) By offering differently-situated explanations for documented phenomena and differently-situated answers to common research questions;
(iii) By increasing the authority of claims, where findings from different analyses in relation to the same question or the same phenomenon were coincident;
(iv) By qualifying the nature of claims, where findings in relation to the same question or the same phenomenon were inconsistent or contradictory;
(v) By providing a critical perspective on the capacity of any particular theory to accommodate and/or explain particular phenomena, in comparison with other theories employed in analyses related to the same events in the same setting;
(vi) By facilitating the synthesis of the results of the parallel analyses for the purpose of informing instructional advocacy.

The derivation of all findings from the same data source through the application of all analytical approaches to the same setting greatly strengthened the project's capacity to realise these six purposes. In particular, multi-theoretic research designs integrate the activity of research synthesis into the research design as an essential element. The goals of research synthesis (Suri & Clarke, 2009) should not be limited to normative convergence on some form of best practice. In developing instructional advocacy arguments, it may be the identification of contingencies on any recommendations that offers greatest utility, by identifying combinations of context and action most likely to promote locally significant outcomes. Multi-theoretic research designs are intended to inform both theory and practice.

"I DON'T PAY ATTENTION THE WHOLE TIME": SCIENCE STUDENTS NEGOTIATING SOCIAL IDENTITIES AND PRACTICE[3]

This section reports findings from a study that sought to identify the circumstances under which participating students were positioned as agentic, and it supports an argument for a discursive approach to the study of agency.

Studies of student agency in science education have previously adopted ethnographic methodologies, using interviews and observations of particular students both in an out of their science classrooms in order to: a) determine the student's goals for the future, b) observe the student's actions that aligned with the student's goals and, c) determine the state of affairs both before and after student's actions in order to detect change related to the achievement of the student's goals. Based upon the ethnographic evidence, researchers have constructed students in research accounts as responsible for their actions and for bringing about changes.

Rather than assigning responsibility to students as described above, this study, in recognizing the constitutive force of language (Harré, 1992; Potter, 2001), sought to investigate science classroom discourse and identify moments in which students indexed responsibility to themselves. Of interest in the study was whether or not actions that the students indexed to

[3] This section summarises the second presentation by Arnold.

themselves as a responsible agent were taken up as legitimate in the classroom discourse. Therefore the response of others was taken into account in the discursive analysis of meaning making as the realization of classroom storylines and positionings.

Data Generation and Analysis

The research was conducted as an instrumental case (Stake, 2005) and the main source of data were the video recordings described earlier. The year-seven science class occurred at a large, multi-ethnic, suburban, government secondary school in Melbourne, taught by an experienced and well-regarded science teacher. As noted, the science lessons were filmed for the duration of an entire unit of work on ‘The States of Matter’. The research took place in the last term of the year.

Focus students for this analysis were three female students, who had been very successful in science assessment tasks throughout the year, and who habitually worked together during small group tasks. The focus students wore microphones on lanyards during the lessons and participated in video-stimulated, post-lesson interviews on a rotating basis. These interviews, the researcher’s observational notes, copies of lesson planning documentation and work produced by all students in the class provided supplementary information for clarifying meaning in the classroom discourse.

The audio tracks from all videos were transcribed. Conversations about science or whilst doing science in which the focus students participated were selected for the study. Phonological transcripts of these conversations were generated as data for the study.

A coding system, drawing upon the work of Muhlhaüsler and Harré (1990), was developed by the researcher for the purpose of identifying speech-action in which the focus students indexed responsibility to themselves. The coding system was based upon indexical features of our language that speakers can use to index their responsibility such as pronoun use, modality and tense, and together these grammatical features have been called by the resesarcher ‘the grammar of agency’.

The meaning of the students’ language use was analysed in the context of the conversational episode in which the students used the grammar of agency. Meaning was analysed using discourse analysis in social psychology (Harré & Langenhove, 1999a; Wood & Kroger, 2000), and in terms of the storylines and positionings that were realized jointly by the participants in the conversation. Nine of these conversational episodes were used to communicate the findings of the study because they exemplified variability in the way the girls indexed responsibility to themselves and were representative of the way in which the girls’ actions were taken up by others in the classroom discourse.

Results

This sample analysis focuses on one of the focus student’s (Tasha’s) use of the ‘grammar of agency’ to position herself and her friends as responsible for actively seeking the scientific knowledge. Tasha had identified the knowledge she lacked and pursued the knowledge by asking her friends, *“What is the Particle Theory?”.* However, her friend, Kesar’s response was, “You’re seri(h)iosly asking me that?”. The social force of Kesar’s utterance was Kesar’s repositioning as not responsible for knowledge seeking. Subsequent to Kesar’s repositioning, Tasha published the biographical “small story” (Bamberg, 2004): *“I don't pay attention the whole time… seriously! I haven't heard about the Archimedes in the bathtub thing”*, which had the function in the conversation of repositioning Tasha in alignment with her friend. The biographical story was face-saving for Tasha and the dominant storyline in their conversation became, ‘Students’ as responsible for passively receiving scientific knowledge’. The analysis of the function of Tasha’s biographical story illustrates the importance of the distinction made by discursive psychologists (Harré & Langenhove, 1999b) between the storying of oneself in autobiography and the realisation of one's position in an ongoing conversational storyline for the development of one's social identity and the realisation of social practices.

Discussion

The girls' actions can be understood in terms of a conversational background in which their social identities as members of a student group who were not expected to know the particle theory were realised. Rather than expressing her own lack of knowledge of the particle theory, Tasha's statements *"I don't pay attention the whole time… seriously! I haven't heard about the Archimedes in the bathtub thing"* were practically orientated towards maintaining solidarity with this student group.

In this way, the collectively realised classroom practices constrained Tasha's development of a social identity as an active seeker of knowledge. Her social identity as a knowledge-seeker was not taken up as viable within the girls' small group and was not published beyond their small group, limiting her opportunity for being positioned as agentic. The findings of the study suggest that reflexive attention to student inquiry and collaboration could enhance opportunities for students to be positioned as agentic. This is supported by Mercer and his colleagues (eg Mercer, Warwick, Kershner, & Kleine Staarman, 2010), who found that the teacher's "vicarious presence" was an important factor in determining the degree to which students engaged in collaborative, dialogic activity.

A goal of this study was the development of a "workable" definition of student agency as a form of discursive practice in which students are positioned as responsible agents. The focus of this study was a discursive psychological account of the variability in agentic positioning by three academically successful science students. By focussing on agency as a discursive practice it was possible to show that the participating students' opportunities for developing social identities as responsible agents within science was constrained by their joint action directed towards the passive reception of scientific knowledge. This illustrates the potential utility of a discursive approach in studying agency and supporting reform efforts in science education directed towards student inquiry and dialogic activity.

STUDENTS' LANGUAGE USE AND ITS RELATION TO THE REQUIREMENTS OF SCIENCE INSTRUCTIONAL TASKS[4]

This linguistic analysis was motivated by an interest in understanding the challenges that students face when appropriating and employing the language of school science in the classroom context. There are at least three assumptions underlying this study. The first and foremost assumption is that learning language of school science is constitutive of learning science (e.g., Lemke, 1990). This assumption provides the main impetus of this study. The second assumption is that learning in the science classroom involves learning its social practices, of which responding to instructional tasks constitutes an important aspect. A third assumption is that the use of language is situated and functional, which implies that language use can vary with the requirements of a task. This assumption is in line with the use of Systemic Functional Linguistics (SFL) framework as the analytical lens (Halliday, 1994).

In this study, each written explanation from students was first examined at both content and lexicogrammatical (LG) level. Subsequent to both content and LG analysis, we compared and contrasted a set of explanations found in students' practical reports with another set of explanations found in their test papers. This method of comparison involved the identification

[4] This section summarises the report authored by Seah, Clarke & Hart

of qualitative differences in language use between the two sets of explanation that might be related to the specific requirements of each task.

The analysis was guided by the following research questions:

1. What are the similarities and differences in the students' use of LG resources between the two tasks?
2. What are the similarities and differences in the requirements between the two tasks?
3. What are the possible connections between the students' language use and the requirements of the tasks?

Data Generation

Among the data generated, the most relevant for the present study were two sets of written explanations completed by students. Below is a description of the source of these explanations:

I. Practical report on expansion

Mr. Gardiner distributed a practical worksheet, which described three activities:

Activity A: Students were required to pass a metal ball through a ring before and after heating (an example of expansion of a solid).

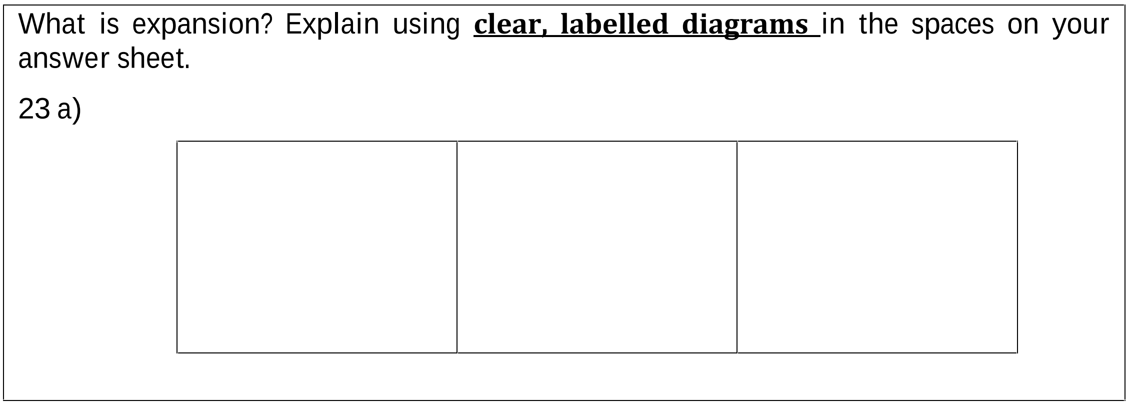
Activity B: Students were asked to fill a flask with coloured water and fit a stopper with a piece of glass tubing through it, before putting the flask in a container of hot water for a few minutes and then subsequently in a container of cold water (an example of expansion of a liquid).

Activity C: This involved heating with a Bunsen flame an empty conical flask, the mouth of which was covered with a deflated balloon (an example of expansion of a gas). Unlike the two activities above that were performed by the students themselves, this activity was demonstrated by the teacher.

For each activity, the students were told to record in their practical book: (i) their prediction of what they thought would happen; (ii) their observation of what happened; and (iii) their explanation for what happened.

II. Test item on expansion

A week after the practical task on expansion, the students sat for a test on the topic "States of Matter", which included a test item on expansion (see Figure 3). As with the practical task, this test item required students to provide an explanation. Data from the lesson videos and interview videos constituted supplementary data useful for understanding the context and for triangulating the meanings ascribed to the written language.


What is expansion? Explain using **clear, labelled diagrams** in the spaces on your answer sheet.

23 a)

Figure 3: Test item on 'What is expansion?'

Analysis

1. Content analysis I: Classifying all students' explanations according to their content using different coding categories referred to as "explanatory foci". Altogether, three explanatory foci - each addressing a specific aspect of expansion – were identified from among the two sets of explanation:

- Macro reference: represented expansion at a macro-level by describing the perceptible aspects of the phenomenon;
- Submicro reference: represented expansion at the submicro-level by interpreting the phenomenon in terms of the particle model of matter;
- Causal reference: invoked a cause (e.g., an external agent or a condition) that brought about the expansion.

2. LG analysis using SFL: The following analytical categories from the SFL perspective were utilised to classify the LG resources employed by the students into linguistic classes:

- *Process*: is typically expressed by a verb or a verbal group and is associated with a small set of *Participants* such as *Medium*, *Agent* and *Range*
- *Medium*: is typically expressed by a noun or a nominal group and is the indispensable *Participant* without which the *Process* would not 'exist'; both the *Process* and the *Medium* constitute the core of the clause, which is the unit of the LG analysis
- *Agent*: is also typically expressed by a noun or a nominal group and is 'the entity that does or acts; the cause or instigator of a process' (Lemke, 1990, p. 222)
- *Range*: can be expressed by a noun or an adverb and refers to 'the limits, extent, or nature of what the process does' (Lemke, 1990, p. 222)
- *Circumstance*: is prepositional phrase, adverbial group, or nominal group that express the circumstances (e.g., of reason, of condition, of location, of means etc.) associated with the *Process* or the *Participants*

These linguistic classes enabled us to differentiate the function that LG resources served to realise scientific meaning. LG analysis highlighted the similarities and differences in the use of LG resources among the students' explanations, facilitating the next phase of analysis.

3. Content analysis II: This phase involved identifying the diversity of meanings realised within each explanatory focus.

Findings

Several ways in which the task requirements might have shaped students' use of LG resources were identified. Specifically, the similarities between the tasks (e.g., the focus on expansion and the requirement to "explain") might have contributed in part to the following similarities between the two sets of explanations: the presence of the same three explanatory foci; the same explanatory focus being associated with a common set of LG resources and addressing the same aspect of expansion; and the same diversity in the types of explanation found among the responses for each task. On the other hand, the differences in nature between the tasks (e.g., specific instance of expansion versus expansion in general; no request to use diagrams versus with such a request) might have contributed to differences between the two sets of explanations that included: the presence/absence of purely causal type of explanation; the diversity of instances of expansion; the presence/absence of certain scientific meanings; the frequency of LG resources employed to link the various explanatory foci together; and the frequency of "it" being employed indiscriminately.

From the findings, we can postulate several mechanisms through which the students' language use might have been shaped by the requirements of a task. In the case of the practical activities, the task determined the observations expected and these in turn shaped what and how particular LG resources were employed. The way students employed LG resources could also be mediated by the students' interpretation of the requirements of the task and their awareness of the differing requirements of the various tasks. The role of the task itself in shaping students' use of LG resources suggests that learning the specific requirements of science tasks is part and parcel of 'the ways of knowing and practices of school science' (Driver, et al., 1994, p. 11) that students need to be 'enculturated' to successfully integrate into the community of the science classroom. For instance, the diversity of the students' explanations in terms of types in both sets of explanations suggests that some students were not clear about what it meant to explain in the context of a science task. As students may have varying interpretations of what a task asks of them, teachers may need to discuss and explicitly unpack the requirements. This study shows that by exploring the possible ways in which a task can shape students' use of LG resources, we can expand our understanding of the challenges that students face when they are required to employ the language of school science in the classroom context. Finally, an understanding of how the requirements of tasks could affect students' responses may also assist in lesson planning by suggesting what kinds of task could be suitable for different stages of instruction.

DISTRIBUTED COGNITION VS. REPRESENTATIONAL PERSPECTIVES ON A CLASSROOM SEQUENCE ABOUT MATTER[5]

Comparison is made between two distinct analyses of the same sequence of science lessons on the topic of matter, involving macroscopic and particle ideas, the first using distributed cognition and the second a representational, semiotic perspective. Through such a comparison, an attempt is made to explicate some key similarities and differences of the two theoretical lenses that could afford a better understanding of the affordances of each theory and how each of them could contribute to advancing our thinking about science teaching and learning in classrooms.

Data Generation and Analysis

The lessons analyzed formed part of a three-lesson sequence on the topic of states of matter, but with a specific focus on the concept of density. The concept of density was only addressed in Lesson 2 and Lesson 3. Lesson 1 provided some background information regarding what the students knew about the three states of matter and the particulate nature of matter, which had some influence on student interpretation of density in the two lessons that followed.

Distributed Cognition

Key to the analysis is the interplay between student prior knowledge, the resources made available in the classroom (including physical, conceptual, and symbolic artefacts), and processes (for example, classroom discussion, teacher demonstration). The key question in the DCog analysis is how the interplay between the three components contributes to changes in patterns of interaction (such as ways of seeing, talking and thinking). The analysis of learning outcomes focused on the work of four male students, who worked together throughout the sequence. It is useful to outline briefly the key instructional acts undertaken during the three lessons in question:

1. An official definition was introduced by the teacher, drawing student attention to the formula on a worksheet. In the formula, density takes the form of mass being divided by volume;

2. To illustrate the meaning of density, the teacher presented two blocks of metal to the class: lead and aluminum. Both blocks were cubic in shape and of the same volume (see Figure 4).

[5] This section summarises the presentation by Xu and Tytler

As the teacher explained in the post-lesson interview, the demonstration of the two blocks was intended to show that the size of an object does not matter but substance matters. The two metal blocks served as an important cognitive artefact for student sense making of the density concept. Cognitive artefacts, in DCog terms, are man-made physical objects for the purpose of aiding, enhancing, or improving cognition (Hutchins, 1995). In this case, the two blocks provided a physical embodiment of the concept of density;

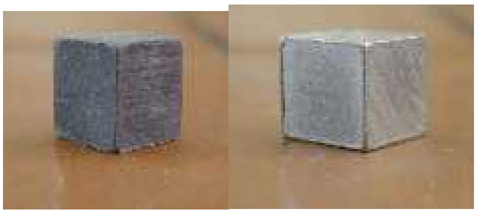


Figure 4. The two metal blocks (lead and aluminum)

3. A third event in the density lessons was the practical activity on measuring the density of a candle and a marble. According to the post-lesson teacher interview, the practical activity was intended to allow students "to get a physical feel for a concept", and "to introduce the term density as mass divided by volume" [0:18:10, L02-INT_T]. In this practical activity, one of the focal artefacts was the worksheet on measuring the density of two objects: a candle and a marble, which set out the aim, materials, methods, and questions for discussion. Like other cognitive artefacts (e.g. the two metal blocks), the practical worksheet was created with an intention to influence the practice of the user in particular ways. This worksheet prescribes the procedures for measuring the density of a candle and a marble, and it serves two main functions: as an instructional device that guides student action and as an inscription device that documents experimental results.

The DCog analysis highlights the important role of different artefacts in mediating student participation in collective activities and student sense making of science. The employment of physical artefacts, such as the two metal blocks, served as a common referent for anchoring the classroom discussion on density. The presence of the two metal blocks also enabled the students to interact with the abstract scientific concept in a concrete way by directing their attention to the features of the two blocks that were made relevant in the classroom interactions. In particular, it gave emphasis to the mass and the number of particles in determining the density of an object, which were later appropriated by many students to be the key determining factors for the density of a candle and a marble. On the other hand, the presence of the two blocks blinded the interlocutors (the teacher and the students) to a potential mismatch in their focus of attention: the density of an object and the density of a substance, since they assumed that they were referring to the same thing. Despite the teacher's intention to show that density depends on the substance of an object, both the teacher demonstration and the student practical work drew student attention to the specific properties of an object, such as mass and volume. It can be argued that underlying the difficulties in understanding the macroscopic and microscopic relationship is the lack of emphasis on the notion of "substance", which could potentially provide a conceptual bridge between the macroscopic and the microscopic properties (see Xu & Clarke, in press, for a more complete analysis of the two lessons on density).

A Representational Perspective

Recent work has focused on the need for students to be guided to construct and negotiate representations as part of learning to reason with these epistemic tools (Hubber, Tytler & Haslam, 2010; Waldrip, Prain & Carolan, 2010). Pragmatist perspectives (Peirce, 1931-58) have been used to interpret student learning and reasoning in terms of the triadic relationship between meaning making, multiple representations and their real world referents. This research analysed the learning environment in terms of challenges and supports it afforded students to coordinate the multiple representations involved in constructing explanations of density and the properties of matter.

The teacher's stated main aim in these lessons was to establish the macroscopic, mathematical definition of density through the formula D=M/V. From the perspective of Peirce's triadic model of meaning making, this involves linking the representation (the formula) with the real world referent in a 'weaving' process by which the capacity of the representation to make sense of phenomena is evaluated and its meaning refined through use.

Analysis of the video record of the three lessons related to density demonstrated the multiple representations that were introduced by the teacher to establish the meaning of the term. These included mathematical formulation of the mass-volume relationship, tabular representation of mass, volume and density associated with an experiment, role play of particles to establish differences between solids, liquids and gases, verbal and written explications, as well as the use of physical artefacts such as the aluminium and lead 'density blocks'. The analysis has illustrated the complex coordination of a series of partial and selective representations necessary to achieve a flexible understanding of density, and the demands this coordination places on teachers to support students in apprehending the features and purposes of the representations, and in making connections between them. Analysis of the representations, demonstrated:

- The need to explicitly support students in understanding the form and function of the various representations and the cost in this sequence of presenting each representation without adequate framing and negotiation;
- The need to frame student challenge activities to allow them to adequately explore and evaluate representations as making sense of perceptual phenomena, and the cost of having scripted, limited opportunity to do this. Thus, for instance, the mathematical expression for density was not utilized by students in a way that demonstrated its capacity to make sense of patterns of mass, volume and flotation in a range of materials;
- The need to acknowledge the selective nature of representations and the need to support students to coordinate a range of representations across different modes, rather than have them introduced and discussed largely independently and with limited reference to each other.

The representational analysis demonstrates the complexity of supporting student understanding of the density concept, and provides an interpretation of the difficulties recognized in the literature (confusion between substance and object, of difficulty of dealing with ratio, and of difficulty with particle ideas) as being fundamentally representational in nature. The teacher in this sequence introduced a range of potentially powerful activities including particle role-play, practical experiences, a tactile demonstration and extended discussion. However, perhaps due to time constraints, and because of the way the open classroom discussion was diverted by students' unanticipated exploration of particle ideas, there were limited opportunities for consideration of the form and function of each representation of density or of the way they interrelated. From a representational perspective this imposed severe limitations on the achievement of a flexible understanding of density.

Discussion of the comparison of Distributed Cognition and Representational Analyses

The first point to make about the two theoretical perspectives is that they focus on different units of analysis. DCog theory was developed to explain the way knowledge and learning are distributed within and across systems, in this case the classroom system, whereas the representational perspective focuses more centrally on the nature of individual meaning making, leading to consideration of how representational resources are opened up in the public space to support this. The DCog perspective highlights the mismatch in the focus of attention between the teacher and the students, and the limited connection between the macroscopic and microscopic views of density. The representational perspective highlights the mismatch as a lack of explication and negotiation of the multiple representations through which density is understood. But each perspective has its own limitations. Distributed cognition arose from studies of workplace settings, and therefore lacks a pedagogical view about how things should be or could be in the classroom. The representational perspective, on the other hand, has a strong literacy focus, but is less well developed to analyze situations involving many physical resources, such as science practical work. The two theoretical perspectives together provide a richer interpretation of the classroom practice studied.

Both theories come from a socio-cultural perspective that acknowledges the role of a variety of artefacts including language and inscriptions, in mediating learning, or generating meaning. The theories differ however in the emphasis they place of aspects of the classroom processes. Thus, while the representational perspective properly includes physical artefacts as having representational value, its focus has tended to be on multimodal inscriptions of various kinds as part of the argument for a literacy based perspective on learning and knowing. The aluminium and lead density blocks figure significantly in both analyses, and both theories concern themselves with their meaning in use, but their role is perhaps more naturally emphasized within the DCog perspective. This is because of the historical emphasis of DCog on how physical tools and other kinds of artefacts can transform the nature of the tasks to be performed by people.

The two theories allow distinct perspectives on teaching and learning, together providing a richer interpretation of the sequence than either on its own. The two analyses uncovered different perspectives on the relationship between physical and conceptual artefacts mediating learning, and on the nature of student learning and understanding. It is argued that such an analysis, utilizing a common data set, allows us to better understand the particular affordances of each theory and how constructs such as ‘artefact’, ‘representation’, ‘conceptual’, or ‘coordination’ sit in different relations to each other within the two theories.

CONCLUDING REMARKS[6]

In this symposium, we provided a demonstration that the theoretical choice one makes not only constrains the particular type of questions that one can ask and the particular type of phenomena that one can investigate, but also orients one towards providing a particular line of explanation for the question under investigation. We have illustrated this with parallel analyses of the same classroom events. These parallel analyses illustrate the capacity of each theory to address the connection between learning and instruction, to accommodate and to predict the likely benefits of particular instructional approaches.

The explicit comparison of analyses undertaken using Distributed Cognition and Representational perspectives has implications for the CCSC project’s goal of facilitating the interrogation of theory (as well as the illumination of setting and process). Specifically, the two theoretical perspectives (Distributed Cognition and Representational Analysis) occupy the same cognitive territory, and to a large extent have overlapping histories in their adherence to material interpretations of knowledge, and to notions of mediation. Unlike analysis involving positioning theory for instance, or systemic functional linguistics, which focus respectively on student agency and lexicogrammatical resources, DCog and

[6] These concluding remarks incorporate comments from the symposium’s discussant: Vaughan Prain.

representational perspectives both purport to deal with the way knowledge is constructed and enacted. These similarities throw up more sharply the relationship between the theoretical constructs, and the different foci, of the two theories.

The interpretations offered by the two theories appear in large part to be compatible, but their foci of attention of attention are different. For DCog, the distribution is across artefacts and people in a classroom, while Representational perspectives look at the way individual knowledge requires coordination of (is distributed across) multi-modal representational resources which are opened up and negotiated in the public space of the classroom. The two theories thus take a similar stance towards learning and knowledge, but from the perspective of the system, and the individual, respectively. The analyses informed by Positioning Theory and Systemic Functional Linguistics can also be distinguished by their foci of attention. Yet, the social realization of student agency and the use by those same students of lexicogrammatical resources are connected by the recognition that both activities are mutually constitutive of the students' engagement with the learning of science.

The interdependence of theory and analytical results has significant implications for our understanding of the role of theory in researching science classrooms. It is only through comparing the parallel analyses of data generated from a common data source that the core similarities and differences between theoretical lenses can be made explicit. In this way, new knowledge could be established with regard to how the various theories could possibly be compared or combined to inform research and practice. It is not our intention to challenge the value of research studies conducted from a single theoretical perspective. In fact, each presentation reports precisely such mono-theoretical accounts. The challenge is to integrate theories of the learning task, theories of learner attributes and theories of acquisition and participation processes in the cause of building theory or theory networks to inform classroom practice.

Our goal has been to explore some of the issues associated with the implementation of a multi-theoretic research design. If we are to progress as a community, we must develop methods by which we can contrast, connect and learn from our extensive and continuing research efforts. Multi-theoretic research designs attempt to exploit the value of analysing the same setting(s) from a variety of theoretical perspectives. We would like to suggest that the benefits include: increased insights, less partial portrayal, and the capacity to interrogate and refine both setting(s) and theories.

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THE IMPACT OF PHYSICAL EXPLANATIONS ON SECONDARY STUDENTS' KNOWLEDGE ACQUISITION IN THERMODYNAMICS

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Abstract: In the process of science teaching, at some moment, some kind of explanation has to be given to the students. These explanations can vary in most different ways. One aspect is that different physical quantities can be used to explain the same phenomena. The objective of this research is to determine whether students' knowledge acquisition depends on the use of different physical quantities in the explanations.
In principle an experimental comparative study with pre-post design and follow-up test with two student groups was chosen. One student group used the physical quantities temperature and entropy to learn basic thermodynamics. The other student group used the physical quantities temperature and thermal energy. We must note that an uncommon concept of entropy was taught, which is based on students' alternative frameworks and not on concepts of statistical physics. To minimize confounding of the results by, e.g. the teacher variable, a computer based learning environment was designed and administered to N=184 secondary students at the age of 14 to 16 years in southern Germany. Knowledge acquisition was measured with a paper-and-pencil test and evaluated statistically using analysis of variance and analysis of covariance, considering students' previous knowledge as a second independent variable. The students instructed with explanations using the physical quantities temperature and entropy have a significantly higher knowledge acquisition.

Keywords: physics learning, thermodynamics, explanations, knowledge acquisition, physical quantities

1. BACKGROUND AND PURPOSE

In physics (e.g. in thermodynamics or mechanics), sometimes different physical quantities can be used to describe the same phenomena. In general, scientists choose those physical quantities which best provide the solution to a given problem. In science teaching, however, different physical quantities lead to different explanations because they trigger different mental representations and models. For students these explanations can therefore vary in difficulty. Hence, the question rises of whether the use of certain physical quantities with their associated explanations has an influence on students' knowledge acquisition. A long German research tradition about these questions exists. Some studies indirectly indicate this effect, as the underlying concepts of a given physical explanation do influence students' physics learning (e.g. Herdt, 1990; Wiesner, 1994; Gleixner, 1998; Bader, 2001; Starauschek, 2001; Wilhelm et al., 2010). However, almost all of these existing studies, except Wilhelm et al. (2010), are confounded with extraneous variables, e.g. the teacher variable. In our study we have tried to eliminate this problem by using a computer based learning environment to be able to measure exactly the effect of the variable "physical explanation" based on the choice of physical quantities.

2. RATIONALE

Two different approaches for teaching senior high school students basic thermodynamics are compared. Usually, the physical quantities “temperature” and “heat” are used to describe and explain thermal phenomena. One of the key problems in using the physical quantity heat is the term’s different meanings in physics and in everyday language (e.g. Kesidou & Duit, 1993). Even after learning thermodynamics students do not differentiate between the physical quantities of temperature and heat and remain in their alternative (everyday) frameworks (e.g. Kesidou et al., 1995). Alternative approaches teaching thermodynamics use the physical quantities of temperature and entropy (Job, 1972; Herrmann, 1998) or temperature and thermal energy (Muckenfuß & Nordmeier, 2006, 2007). Here, students’ alternative frameworks are addressed in two different ways. First, the extensive aspects of the everyday meaning of “heat” can be interpreted as entropy, and the term “entropy” can be used synonymously with everyday “heat”. This interpretation is not common but physically correct and is discussed in detail in Job (1972). The use of “thermal energy” allows the avoidance of the word “heat” in physics instruction (Muckenfuß & Nordmeier, 2006, 2007). Previous studies, which are confounded, however, indicate higher knowledge acquisition with the physical quantities entropy and temperature (Starauschek, 2001, 2002). In our study, we test this hypothesis in an experimental study and, furthermore, take into account the strong and well-known variable of students’ previous knowledge. To summarize the key hypotheses for this study are:

1. The use of the physical quantity entropy leads to higher knowledge acquisition than the use of the quantity thermal energy.
2. Students’ previous knowledge of thermodynamic concepts leads to different levels of knowledge acquisition.

3. METHODS

The hypotheses were tested in an experimental study with two independent variables: the treatment variable “explanations with different physical quantities (entropy/thermal energy)” and the variable “previous knowledge (high/low)”. This leads to a 2x2 factorial design. The sample (N=184) consisting of students aged 14 to 16 years. All students were randomly assigned to one of the two treatments. After conducting a paper-and-pencil pre-test on the students’ knowledge on basic thermodynamic concepts, both treatment groups were additionally divided into the two subgroups according to their level (high or low) of previous knowledge. The content of the cells of the 2x2 factorial design is shown in table 1:

		TREATMENT	
		entropy	thermal energy
PREVIOUS KNOWLEDGE	high	n = 49	n= 51
	low	n= 41	n = 43

Table 1: 2x2 factorial design

The dependent variable “knowledge acquisition” was measured using pre-, post- and follow-up- paper-and-pencil-tests and statistically evaluated using an analysis of variance and analysis of covariance. The measurement instrument of the variable “knowledge” includes 13 field-tested items (Kesidou&Duit, 1993; Starauschek, 2001; Yeo&Zadnik, 2001; Einhaus, 2007). The reliability for this test (α=.646) and the control variables was determined using Chrombach’s Alpha. The following control variables were surveyed with reliable instruments: interest in physics: α=.845 (Fuß, 2006), intrinsic motivation: α=.886 (Fuß, 2006), learning

strategies: α=.649 (Berger &Hänze, 2004), self-concept of ability: α=.892 (Helmke, 1992) and a standardized test on intelligence: α=.798 Heller et al., 2000). Furthermore, the study time was measured. To ensure that no effect results from the repeated-measure-design using the paper-and-pencil-test, one group of students (N=29) participated in the survey as a baseline group without any instruction given by us or by their regular teachers at their school. This group simply completed the pre-, the post- and the follow-up-test within the same timeframe as the other two groups of students, but was not taught in thermodynamics at all during the time of this study.
To prevent confounding by the "teacher" variable, two versions of a computer based learning environment were developed following the multimedia principle (Mayer, 1997). One version uses the physical quantity entropy. The other version uses the physical quantity thermal energy. Each version has a set of seven computer programs covering the basics in the field of thermodynamics for high school students. The individual computer programs consist of about 30 slides. All slides contain hand drawn pictures, audio and written text. The computer program is basically linear structured. At first a picture is shown and the audio is played (figure 1a). After the audio is done playing the student can choose one of the four options by pushing a buttons: (1) Move back to the last slide, (2) listen to the audio again, (3) read the text themselves (figure 1b) or (4) move on to the next slide:

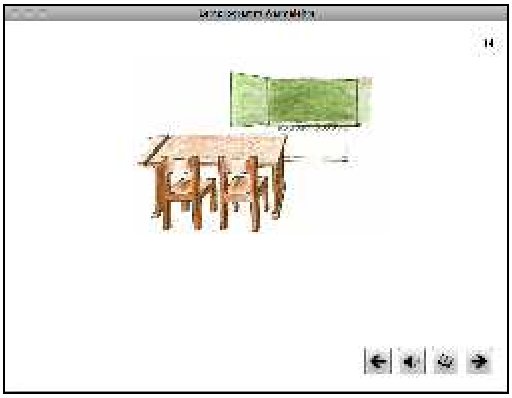

Figure 1a: Slide of the computer program

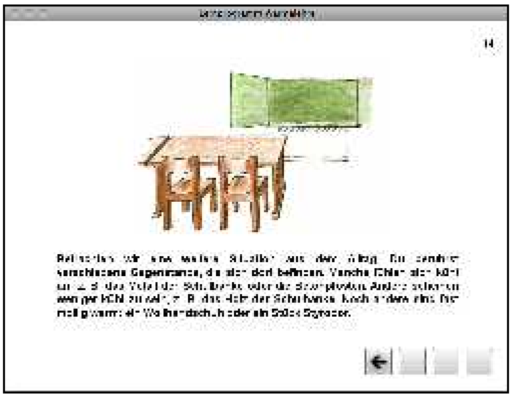

Figure 1b: Same slide of the computer program with the text visible

So even though the slides of the computer program are linear structured individual learning paths are possible. The students can decide how much time to spend on a certain aspect of the topic being taught by listening to audio again or reading the text. Both versions of the computer programs are alike, the pictures are identical, the text and the audio on every slide cover the same content and have almost the same length. The only differences between the two versions are the physical quantities used in the presented explanations. The texts mostly differ only in the names of the physical quantities. An example is given in figure 2a and 2b:

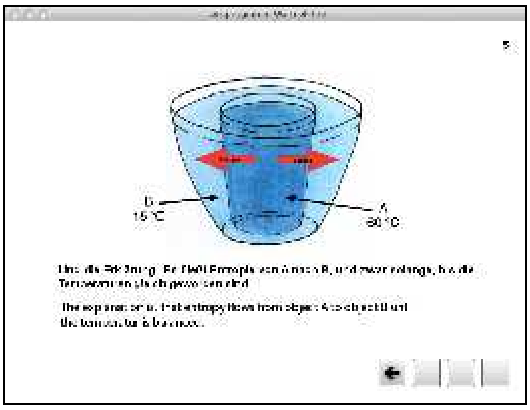

Figure 2a: Version 1 using entropy

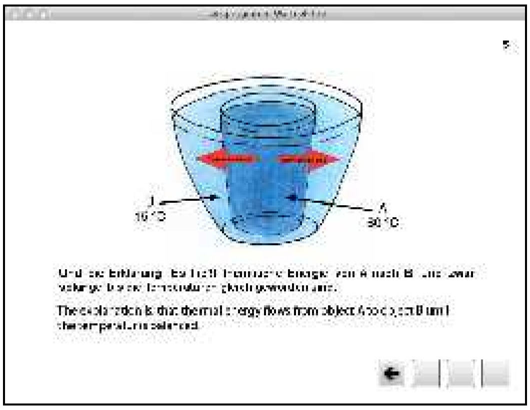

Figure 2b: Version 2 using thermal energy

All students worked separately on their own computer, so that every student could decide how much time to spend with each program. No time limit was given by the instructor. The students worked on three days 90 minutes each using the computer program and doing standardized exercises following each program. More details regarding the design of this study and the computer based learning environment are found in Crossley & Starauschek (2010, 2011).

4. RESULTS

The baseline group did not achieve mentionable knowledge acquisition. The score of the post-test was only slightly higher than the pre-test-score, but the follow-up-test-score was almost identical with the original pre-test-score. All scores did not differ significantly from each other. Therefore the repeated-measure-design seems to have no effect on the students' knowledge acquisition. Moreover, there were no significant differences between the four subgroups of the 2x2 factional design regarding the control variables and no correlation between knowledge acquisition and study time was found (Crossley &Starauschek, 2012 in print).

All four subgroups of the 2x2 factional design had a considerably higher post-test-score.As shown in Figure 3, two main effects were found using analysis of variance: (1) Students learning basic thermodynamics with explanations using the physical quantity entropy have significantly higher knowledge acquisition ($F_{(1, 184)} = 9.932$, $p = .002$, $\eta^2 = .052$) than the other group. (2) Students with high previous knowledge of basic thermodynamic concepts have lower knowledge acquisition than students with low previous knowledge ($F_{(1, 184)} = 8.952$, $p = .003$, $\eta^2 = .047$):

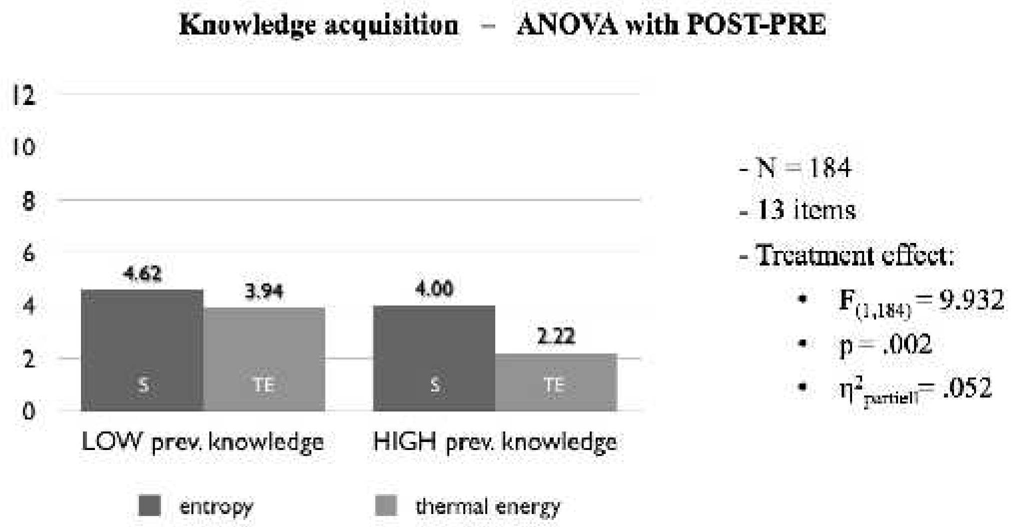

Figure 3: Knowledge acquisition – ANOVA: POST-PRE

It should be noted, however, that because knowledge acquisition was calculated simply by subtracting the pre-test-score from the post-test-score, for students with previous knowledge near the maximum score, it is impossible to have the same absolute gain in improvement as for students with a low level of knowledge.
To verify the stability of this simple method, two other statistical methods to determine the knowledge acquisition were used: (1) An analysis of covariance and (2) an analysis of variance using the hake-factor (Hake, 1998).
The analysis of covariance with the post-test-score as the dependent variable, treatment and previous knowledge as fixed factors and the pre-test-score as the covariate leads to a comparable result ($F_{(1, 184)} = 7.962$, $p = .005$, $\eta^2 = .043$):

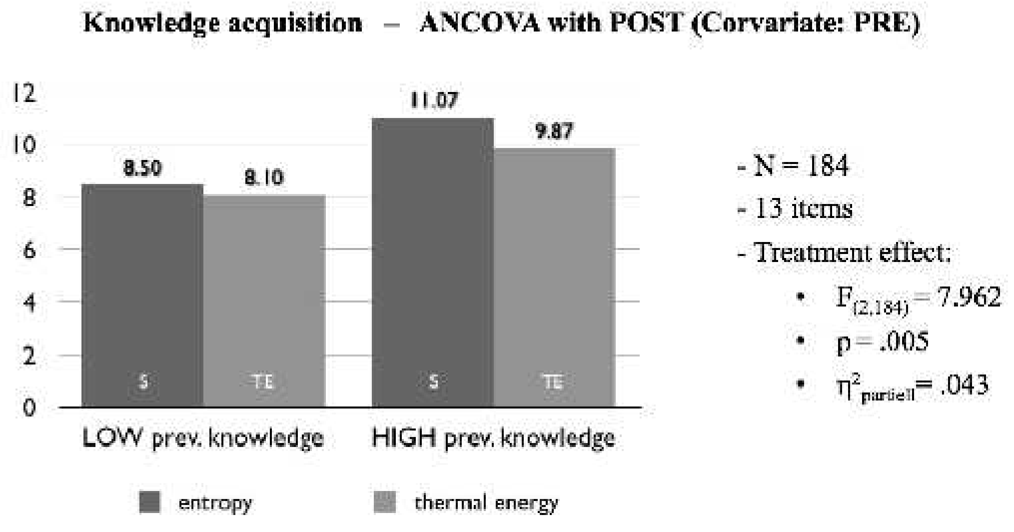

Figure 4: Knowledge acquisition – ANCOVA: POST with PRE as covariate

Again the explanations using the physical quantity entropy lead to significantly higher students' knowledge acquisition. Figure 4 shows that students with a high level of previous knowledge about thermodynamic concepts reach a higher score than students with a low level of previous knowledge. But the gap between these to groups becomes smaller.
Finally knowledge acquisition was determined using the hake-factor (Hake, 1998).When comparing the scores of two tests a person took, the hake-factor takes the maximal possible

knowledge acquisition into account. The data was statistically evaluated using analysis of variance with the hake-factor as the dependent variable and the same fixed factors:

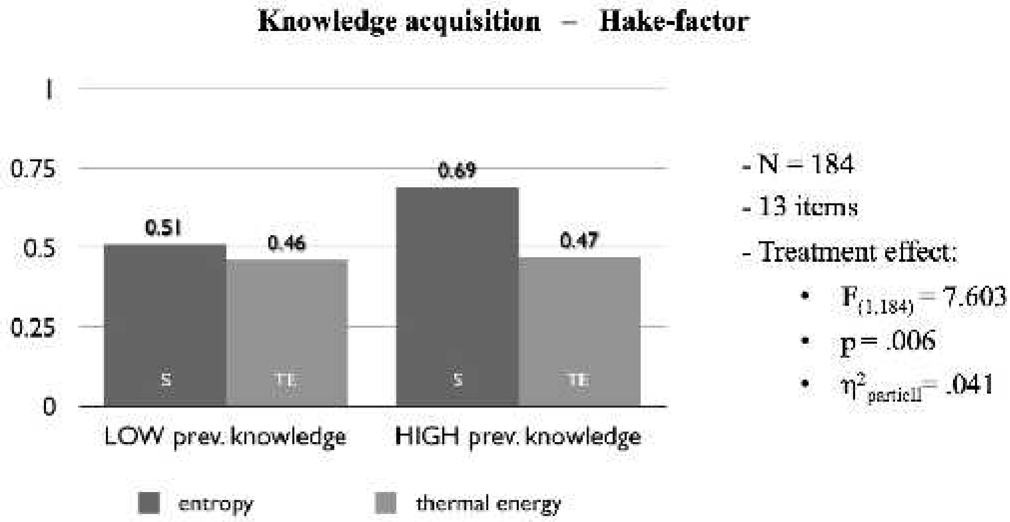

Figure 5: Knowledge acquisition – ANOVA: hake-factor with POST and PRE

The students that had received instructions using the physical quantity entropy reach a significantly higher hake-factor than the other group of students: $F_{(1, 183)} = 7.603$, $p = .006$, $\eta^2 = .041$. Figure 5 also shows that students with high previous knowledge that received instructions using the physical quantity entropy had the highest benefit of all students that participated in this study. The analysis using the follow-up-test results data lead to similar results, simply the effect sizes become a little smaller.

5. CONCLUSIONS AND IMPLICATIONS

The study firstly shows that small variations in the explanations lead to medium effects and can be measured using the experimental design settings described above. Differences between the two student groups result from using two different physical quantities in the teaching environment. It was found that the use of the physical quantity entropy resulted in significantly higher knowledge acquisition than the use of the physical quantity thermal energy. It was also found that the gap between students with a high level of previous knowledge and students with a low level of previous knowledge on thermodynamic concepts becomes smaller for both treatment groups. But students with a high level of previous knowledge that received instructions using the physical quantity entropy had the highest benefit.

The reinterpretation of heat as entropy seems to work well and, in fact, better than the avoidance of the word heat and using thermal energy instead. This study also shows that even a weak intervention can have effects on the learning process that cannot be disregarded.

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A SUSTAINABLE TEACHER TRAINING: APPROACHING MORE SCIENCE CONTENT AND INQUIRY

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Abstract: How can teachers change the way they teach so students get access to more features of inquiry based science teaching and learning? Four teacher educators and researchers worked with five teachers from two schools, to develop tools to analyze teaching sequences. The teachers' lessons were video-taped on two occasions at least with several weeks in between. The films were analyzed and various didactic issues discussed in seminars with the researchers and the teachers. After the first lesson feedback, the teachers were given the challenge to make a teaching sequence paying regard to his/her reflections on our seminar and our analysis of the first lesson**.** We report a case study in which a teacher, Roy, develops his teaching in several respects such as dialogic communicative approaches, writing, and science content. We compare and analyze two of his lessons: the first on Electricity and the other on the Water Cycle. The teacher Roy is able to create interesting lessons in which argumentation and debate are included. With the second lesson Roy showed awareness of the significance of the science content in the dialogue, and he gave a greater subject-matter depth compared to the first lesson, as well as a wider variety of scientific ways including experimental work. The science content was, however, superficial and vague in both lessons. The difficulty of meeting the students in dialogue occurs when the teacher's own knowledge is insufficient. The teacher's awareness of the importance of dialogue in the classroom combined with a greater depth of subject focus, lead to learning opportunities for students that are of benefit for both language and science skills.

Keywords: communicative approaches, teachers professional development, dialogic inquiry, inquiry-based science teaching/learning, writing in science

INTRODUCTION

Teacher training in the form of short-time courses or teachers' seminars with lectures have been shown to have limited success concerning the teachers' reception and implementation of new ideas and skills in the classroom, and over time. The research literature concludes that effective teacher training in contrast to the 'one-shot workshops' or 'top-down cascades training' must be characterized by 1) the teachers helping each other with school activities, and 2) an emphasis on self-instruction and opportunities to practice in a context where the teachers are active and choosing their own goals, and 3) training ongoing over a long period of time 4) support, demonstrations and feedback. (Adey, 2004; Schwille, Dembélé & Schubert, 2007)

This paper presents a case study from science teaching in a Swedish compulsory school. Four teacher educators and researchers have cooperated with five teachers from two primary schools, to develop tools to analyze teaching sequences that will be used as material for reflection in new teachers professional development programs (TPDPs). We have an approach of working with teachers as a ‘community of practices’ (Wenger, 2004), into which the researchers bring knowledge from the research community. The teachers bring the contextual knowledge about the class, the background to the teaching situation, the possible level of framing the science content of lesson, limitations and strengths that are present in the actual situation for the teaching and the relation to the curriculum. We focus on one of the teachers, Roy, and the way he consciously varies his teaching towards dialogic communicative approaches including writing, and the way he frames his teaching in aspects of science content. When working with Roy and his colleagues, we showed and referred to domain-specific instructional theories in research literature. By introducing examples from such literature, the teachers got engagement and inspiration to give priority to science content of teaching in the classroom. The ownership of the final design of the teaching–learning is always in the hand of the teacher, which we find obvious, but needs to be expressed and argued for.

AIM AND RESEARCH QUESTIONS

The overarching objective is to build a sustainable teacher training in science by letting schools and researchers work together for a long period of educational development, and through TPDPs introduce inquiry-based science teaching / learning to stimulate students' engagement in science and technology. Another aim is to challenge the teachers to create science-based lesson sequences in science and technology built on increased awareness of communicative and dialogic approaches in their science classes.

In this paper we like to answer the following research questions:

- What researched-based activities did the teacher use in the lessons?
- How is the lesson time spent on different types of activities?
- What types of communicative approaches are used?
- What lesson activities allow dialogue?
- How is writing used as part of the dialogic science discourse?

THEORETICAL BACKGROUND

Our intention to create ‘sustainable’ teacher training, means that we want teachers to get research-based information that help them look upon their classrooms with new eyes. We find it plausible that teachers with a changed view on teaching/learning are themselves able to create a new learning environment in the classroom. Adey (2004, p.169) argues: ‘Successful implementation of innovative teaching methods through professional development requires a combined approach, providing teachers with information, guidance, and leadership while recognising that no outsider can impose a model.’ Our aim is to inspire teachers to develop a dialogic inquiry based science teaching/learning, in this study *guided* inquiry (Guesti,2008). Dialogic inquiry takes departure in the view that fundamental for dialogic classrooms is the students having self-confidence, and there being trust and respect among students, and between students and teachers. Therefore, the feed-back given from teachers and other students is essential. Students with different backgrounds, different languages, and experiences create the classroom environment. Different opinions clash and lead to further development of ideas. A dialogic teaching requires that students can join in a dialogue with the subject matter, which can usefully be made in writing. This special form of dialogue can also be found when students work in small groups and use *exploratory talks* (Barnes & Todd,

1995) to find the answer to a specific question. Episodes that include dialogic inquiry also mean situations when learners and teachers together explore ideas that are not planned for the lesson, but are initiated by the way the dialogue has taken place during the classroom discussion, for example by students self-generated questions.

Mortimer and Scott (2003) developed a model for the scientific conversation in the classroom in their book *Meaning-making in secondary science classrooms*. The teacher's approach to the talks can be studied in the dimensions of interaction / non-interaction and authoritative (mono-logical) / dialogic. With this model, the conversation can be analyzed by using the talk chains built up. The triadic conversation IRE (initiation-response-evaluation) is typical of the monologue / interactive call. The IRE pattern is often built on question- answer-evaluation, when the teachers make the students “que-seekers” the pupils guess the word the teacher is aiming at. This pattern is distinguished from the dialogic interactive IRFRF pattern (initiation-response-feedback-response-feedback), in which students get more space. The IRFRF pattern of discourse can be found when the teacher instead of asking yes/no questions, encourages and prompts the pupil to tell the class of personal ideas around the phenomenon that is in focus. Mortimer and Scott (2003) emphasized that teachers’ awareness of these different approaches could help them vary between different approaches in an appropriate way. They described further on, the teacher’s responsibility to: 1) present the scientific ideas on the social plane, 2) discuss the ideas with the pupils to help them internalize the ideas, and 3) hand the ideas over to the students to make them their own. In our seminars with the teachers we also discussed principles of dialogic teaching based on Alexander (2004).

Writing is a powerful dialogic means and a tool in the learning process, that makes the student sharpen the thinking and in an intelligent manner use appropriate concepts. In the international writing research there are two main directions, both of them dialogic means but in different ways. One direction, *Writing Across the Curriculum* (WAC), stresses writing-to-learn-strategies, which can be used in all subjects. Spontaneous writing and writing to investigate can help the pupils ”make the content of the subject their own”. This kind of writing can be used in various ways in short “mini-writing” tasks such as: What do you know about…? What is your opinion of…? What solution do you think is best? Why? These texts primarily serve as the student’s thinking tool, discussion and dialogue in groups. The other direction, *Writing in the Disciplines* (WID), stresses the terminology of each subject, its linguistic style and requirements of the subject specific genres, for example the lab report in natural science. In this kind of writing the student’s text has a reader, which is more demanding than writing for his/her own thinking.

METHOD

Through presentations in a seminar series on science education, four teacher educators and researchers made contact with primary school teachers, who were interested in participating in individual training with mentor support, to develop science teaching. Two primary schools and five teachers volunteered to join the project. Initially the teachers were interviewed. The teachers’ lessons were video recorded and analyzed. In seminars feedback on the analysis of science content and communicative approaches was given as well as lectures on teaching with a dialogic approach. Oral and written orientation on recent research was given. After the first lesson feedback, the teachers were given the challenge to make a teaching sequence paying regard to his/her reflections on our seminar and our analysis of the first lesson.

The teacher we follow in this case study, Roy, taught two grade 5 classes (students 10 – 11 years of age). In this presentation we analyze and compare two of the lessons in his class: the first introducing electricity/energy, the second dealing with the water cycle. The lessons have been analyzed in terms of activities, science content and writing. We use the structure for a 'design brief' described by Leach, Ametler & Scott (2010) to follow how Roy implemented the teaching sequences leading to the lessons The Water cycle and Electricity.

Description of the context for the designed teaching

The Swedish Curriculum of 1994 (Lgr 94) was in use during the project period (in August 2011 a new curriculum for the Swedish compulsory school was introduced). The purpose of the physics subject, as described in the curriculum, is based on students' desire to know more about themselves and the world. Particular attention should be paid to the teachers actively helping the students achieve understanding. At Roy's school there are many qualified and experienced teachers, but like Roy, some of them lack science in their teacher qualification. The school has a special task to work with students with Swedish as second language, and up to 75 percent of the students come from non-European countries.

The pedagogic strategies and sequencing of content to be used in Roy's teaching are:
Staging the scientific story, Supporting student internalisation, Handing over responsibility to the students and Design tools.

In order to analyse the lesson activities, the videos are categorised (with time as unit of analysis) with the help of computer programs (Videograph, SPSS), and the percentage distribution of class time on 1) teacher's instructions, 2) scientific discussions, 3) problem solving with the investigation, 4) writing tasks and 5) small-group work. Furthermore, Roy's use of different communicative approaches (Mortimer & Scott, 2003) was categorized in a scheme for dialogic inquiry: interactive dialogic, interactive authoritative, non-interactive dialogic and non-interactive authoritative. The scientific content is categorized into concepts, applications, larger context, and socio-scientific issues. Analyses of Writing Across the Curriculum (WAC) and Writing in the Disciplines (WID) were made, as well as oral and written elements of argumentation.

RESULTS

The lesson on electricity, which we video-recorded and discussed in our seminars with the teachers, lacked full clarification of scientific concepts, it contained no experiments, and no writing. The external environment was presented with a video on hydroelectric power and later on also other sources of energy production were discussed. The lesson ended with a value-training task in which the students were asked to vote for which kind of energy supply they preferred: nuclear power, wind-power, waterpower or solar power.

In the following we are focusing on the second lesson, the lesson on The Water Cycle, where we saw many examples on interactive/authoritative talk as in this situation reviewing an earlier lesson:

Roy:	You remember last Friday we started to do a water test. What did we do, Amanda?
S7:	We had four glasses that we filled with water. So we put one on the shelf, one on your table, one below the electric heater and the one under the sofa.
Roy:	Why did we do it? Why do we put a glass of water at different places?
S7:	To check if it had evaporated.

Roy: Evaporated. Let's check what has happened to the four glasses. We talked about some other things about water, too. I'll write down some key words that you should have in mind today, so you remember what they mean.

Now the students are asked to write down everything they know about the water cycle. After five minutes they discuss in groups of 3-4 students and close with a presentation where each group explains what they come up with. The teacher gives a summary of statements as he draws the sun, water waves and arrows on the blackboard:

Roy: We have a sun, which warms. This is a sea (drawing) - it will conduct heat from the sun (draws stretch down from the sun to the water) - it evaporates water from the water surface (arrows are drawn up from the water surface). We have the energy needed to heat the water. It rises. What rises? Do you know what it's alled?
S1, S2: Steam. Water vapour.
Roy: Yes, and it's a gas. What happens to the water vapour, then?
S2: It goes up to the clouds.
Roy: The formation of clouds of gas is up here. Does it start to rain at once?

One of the problems we face in the conversation above, is that the teacher is not aware of the difference between water steam and water droplets. He draws two clouds on the blackboard to illustrate a cloud with 'gas' and a cloud with water-droplets. The conversation starts as interactive/authorative, but gradually becomes interactive/dialogic. The atmosphere in the classroom opens up for student generated questions:

S4: Cool! It's a weird thing I have always wondered about. Why is the snow white?
Roy: Why is the snow white?
S4: Yes, just white.
S1: It may well be yellow too.
Roy: (all laugh) Yes, if somebody has peed on it, yes. I don't know why the snow is white, it's some kind of crystals that reflect, I really do not know. The ice crystals are white.

The lesson continues by checking from which of the glasses the water has evaporated the most, and to write down the results into a template for a laboratory report with the headlines: water cycle, evaporation, condensation, energy. A last brain-storming started by writing in log-books on the question: Will water evaporate at any other places than rivers, lakes and oceans? After the following group discussions the teacher summarizes what the students have come up with:

Roy: It is your breath. It is hot, then it .... water vapour.
S6: In a sauna, it will be like really hot when you blow on himself. . But when one blows here all is just normal.
Roy: Yes. What more needs water to survive then? Do animals evaporate? Is the only place it evaporates from when doing so? (Roy breathes hard.) Amanda, you can see your breath when it's cold outside. (Makes a gesture from the mouth to show the breath). Is it the same thing in here though I do not see it? Is steam coming out? Have you done like this with a mirror? (Blowing against the palm to illustrate). How is it then? (Several students rush to respond). Foggy, misty. What is this?
Roy: Water vapour.

The communicative approach has become even more interactive/dialogic, as student experiences are told and discussed. Unfortunately the same teacher's view on water steam as water droplets make the science content questionable. The lesson concludes with an experiment that is described in the logbook – the evaporation from the hand put into a plastic bag and sealed with a rubber band.

In table 1 the communicative approaches in the two lessons are compared. The intention to enhance the dialogue towards dialogic interaction has been successful with an increase from 40% to 60% between the two sequences.

Table 1: Percentage distribution of time for different communicative approaches

Lesson	Interactive/ authoritative	Interactive/ dialogic	Non-interactive/ authoritative	Non-interactive/ dialogic
Electricity/Energy	47%	40%	11%	1%
The Water Cycle	16%	60%	23%	0

In table 2 is shown how the natural science content is distributed quite differently between Roy's first and second lesson.

Table 2: Percentage distribution of time for the science content divided into categories

Lesson	Concepts	Application / Natural Phenomena	Wider context	Socioscientific issues
Electricity/Energy	4%	51%	37%	9%
TheWater Cycle	92%	7%	1%	0

Analysing the kind of science content focused in the lessons, we see in table 2 four categories. The science concept part has increased considerably in the lesson that was inspired by dialogic teaching, but all broader contexts have a remarkable decrease.

In table 3 below is shown how Roy used writing as a dialogic learning tool in his science classroom.

Table 3. The use of writing in Roy's classroom

	Lesson I Electricity/Eenergy	**Lesson II Water Cycle**
Writing as a thinking tool and a basis for discussion	no	yes
Writing of specific genres	no	yes
Reporting facts in full sentences	no	yes
Reporting a course of events	no	yes
Arguments supported by facts reported in full sentences	no	yes
Use of specific concepts	no	yes

As can be seen in table 3 there is a big difference as to the use of writing between the two lessons. In lesson I no writing tasks were given at all, while it was an important element in the lesson on the Water Cycle. Roy used writing as a tool for thinking and as preparation for group and whole class discussions, which made the students feel safe and free to express themselves. He also used writing in the lab reports – a very specific genre of natural science, which the students must gradually learn to master.

DISCUSSION AND CONCLUSIONS

During this collaborative project more dialogic elements were included in the lessons in which student questions were discussed and the content problemised. The students were given greater autonomy to express their thoughts, and to participate in a dialogical conversation, both oral and written, with each other and with the teacher. The academic language of natural science was focused, and the students got greater opportunity to expand the vocabulary of scientific concepts. The teacher increased the amount of interactive dialogic conversation, and used inquiry and experiments in several lessons following on each other. The teacher had, by adopting the theoretical frameworks afforded, changed his view on dialogic aspects in the classroom, and on the importance of language for students to become disciplinary discourse participants. New words and concepts are provided to the students by talking and writing exercises – and emphasise is on letting the students express their own ideas and questions. Experiments were planned and guided inquiry gave high engagement among the students. A sign of learning is the relevant questions, which could be seen also in the writing tasks.

In this case study the collaboration between teachers and researchers is built on the teachers' ownership of the teaching content, which is allowed to vary widely. Focus on learning objectives and subject content is strong. The teachers' awareness of their own communicative approaches, of the science content being varied between concepts, applications and broader contexts, and of science writing as a dialogic means, are other important factors. The students had to use the new concepts of the water cycle in several ways, in listening, in writing, in oral, and also by drawing in their lab reports. Consequently, Roy's use of writing as a dialogic and learning tool connects to both the WAC and WID research directions. By varied linguistic use the students strengthened their knowledge.

The teacher Roy is able to create interesting lessons, where argument and debate are included. The science content, however, was in the first lesson superficial and vague. With the lesson on the Water Cycle the teacher showed awareness of the significance of subject content. He was able to give a greater depth and more variety of scientific ways of working and experimental moments. The difficulty of meeting the students in dialogue occurs when the teacher's own knowledge is insufficient. However, Roy, who is not formed by the science education 'canon', has much to teach us about science teaching in risk of becoming too narrow. We are convinced that this teacher has new tools to work with in designing new lessons, and an interest to enhance his own science understanding, with the positive response his students gave him.

We see a great need for more subject knowledge, which cannot be met by simply increasing awareness and use of our tool for analysis of educational content. With the teacher's' experience of dialogue in the classroom and a greater depth of subject content, rich opportunities for students' learning that benefit both the language and science skills would be created. We maintain that the training model described above has the potential to support teachers' learning. A TPDP needs to provide meaningful learning that takes into account the aspects discussed. There is evidence in the literature that the model we are developing together with the teachers delivers the key components necessary for an effective teacher training that leads to teachers learning. We believe that by not only disseminating teaching ideas, but also participating, and by supporting the individual teacher and the team during the implementation and development of ideas in the teacher's own learning environment, we help the teachers to revitalization and increased motivation.

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WATCHING THE SKY NEW REALIZATIONS, NEW MEANINGS, AND SURPRIZING ASPECTS IN UNIVERSITY LEVEL ASTRONOMY

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Abstract: Learning astronomy is challenging at all levels due to the highly specialized form of communication used to share knowledge. When taking astronomy courses at different levels at university, learners are exposed to a variety of representations that are intended to help them learn about the structure and complexity of the Universe. However, not much is known about the reflective awareness that these representations evoke. Using a simulation video that provides a vivid virtual journey through our Milky Way galaxy, the nature of this awareness is captured and categorised for an array of learners (benchmark by results obtained for experts). The results illustrate how the number and nature of new things grounded in *dimensionality, scale, time and perspective* reflective awareness can too easily be taken for granted by both teachers and learners.

Keywords: Astronomy Education Research, Perspective, Awareness, Representations

Introduction

Learning astronomy can be difficult for learners at all levels due to the highly specialized form of communication used to share knowledge in the disciplinary discourse of astronomy. The learners' can be anyone interested in learning astronomy, from amateurs to astronomy and physics graduate students. When taking astronomy courses at different levels at university, learners are exposed to a variety of *representations* with the aim of helping them learn about the Universe. Many of these representations have been created in two-dimensional form (2D) and experts (teachers who are professional astronomers or physicists) involved in this case study wanted the learners in their classes, to come to understand, or better understand, some of the more fundamental processes and underlying structures of the Universe from those representations.

Teachers often take for granted that learners experience, and develop, a three dimensional (3D) representation of the Universe in their minds, i.e., this is an aspect that is often *appresent* to the learners. For example, when teachers introduce nebulas using 2D pictorial representations and 3D verbal representations a visual appresentation aspect is introduced. Such appresentation aspects are further enhanced when time, as the forth dimension, is introduced.

Simulation videos are often used to dynamically introduce learners to the structure and complexity of the Universe in 3D. However, little is known about the learning possibilities that such a collection of representations (representation affordance), may present to reflective learners (cf. Schön, 1991).

Our case study was designed to initiate an investigation into the nature of this awareness. Our starting point has been to use a highly regarded and widely used simulation video that sets out to illustrate some of the fundamental structural components of our Universe by taking viewers on a virtual reality journey through and out of our Milky Way Galaxy. Results in terms of evoked awareness for groups of undergraduates and experts' are described and discussed.

Research setting

There is a growing international interest in viewing learning, in areas such as physics and astronomy, from a disciplinary discourse perspective. Such a perspective suggests that challenges to learning may be related to difficulties embedded in the handling of the highly specialized forms of communication used to share knowledge within a discipline (for epistemic examples, see Driver & Ericksson, 1983; Säljö, 2000; and diSessa & Sherin, 2000). Our study is hence built around a disciplinary discourse modelling of how both teachers and learners work with this communication (Airey & Linder, 2009) using a particular example of a simulation video that is widely used to dynamically introduce learners to the structure and complexity of the Universe in 3D (*Flight to the Virgo Cluster* which can be found at http://www.ifa.hawaii.edu/~tully/outreach/movie.html). This video introduces a viewer to the Milky Way in colour and three-dimensional orientation across millions of light years of simulated travel across the Milky Way. The research agenda sought to capture the reflective awareness of fundamental structural components of our Universe that was afforded to viewers as they engaged with the first million light years of the video journey.

Research question

What is the nature of awareness afforded by the disciplinary representations encounted in a computer simulation of travelling through the Milky Way Galaxy?

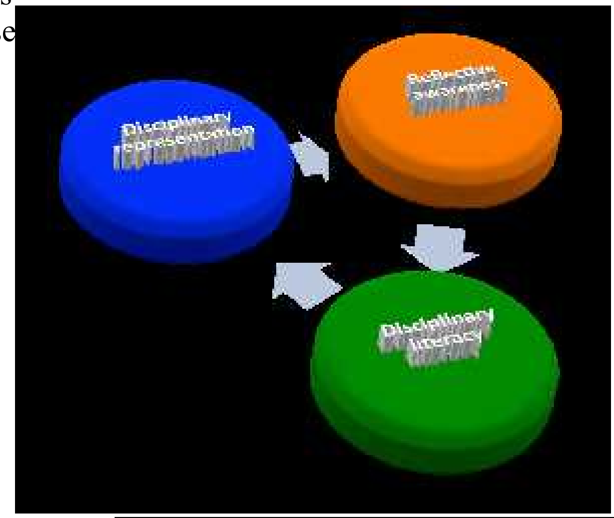
Theoretical framework

The research framing draws on the Airey & Linder (2009) modelling of disciplinary discourse in relation to semiotic representations and on Schön's (e.g., 1991) development of John Dewey's formulation of reflection in a learning situation.

Airey & Linder (2009, p. 28), using a multimodal lens (cf. Kress et al., 2001), defined disciplinary discourse as "the complex of representations, tools and activities of a discipline". They use their modeling of disciplinary discourse and the related learning possibilities of different disciplinary representations to develop a "generative metaphor" (Schön & Argyris, 1978) of *discursive fluency*: "By discursive fluency we mean a process through which handling a mode of disciplinary discourse with respect to a given disciplinary way of knowing in a given context becomes unproblematic, almost second-nature. Thus, in our characterization, if a person is said to be discursively fluent in a particular mode, then they come to understand the ways in which the discipline generally uses that mode when representing a particular way of knowing" (Airey & Linder, 2009, p. 33).

For a learner to become discursively fluent in introductory parts of the disciplinary discourse of astronomy, we argue that the concepts needed are those we illustrate in Figure 1:

- **Disciplinary representation:** the collection of disciplinary representations that makes up the 'disciplinary discourse' that enables disciplinary knowledge sharing.
- **Disciplinary literacy**: the ability to appropriately participate in the communicative practices of a discipline (Airey, 2011a; 2011b).
- **Reflective awareness**: the learning affordances that engagement with a collection of representations facilitates. The notion of reflection here is drawn from the work of Schön (for example, 1983) in that it is related to our learning experience and the noticing of new things and the noticing of things in new ways.



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Recent reviews of astronomy education research show that almost all of the work done in this field has taken place at a pre-university level and that very little has been grounded in a disciplinary discourse perspective (Lelliott, 2010; Bailey, 2011). The work reported on in this paper goes towards addressing both shortcomings. It attempts to provide further understanding of the astronomy learning experience.

Method

From a pilot study, conducted on a small group of nine physics learners and one astrophysicist expert, we obtained reflective descriptions showing how learners and experts differed in how they chose to describe what they noticed when viewing the Flight to the Virgo Cluster simulation. The learners descriptions lead to fewer and characteristically less sophisticated categories (e.g. description of the Milky Way, relative distances between stars, nebulas and galaxies) whereas the experts' descriptions, besides being characteristically more sophisticated (e.g. shape and colour of nebulas, the 3D representation of the video versus elapsed time, stars and exoplanets, gravity and the shape of the galaxy), were also larger in number.

A survey was undertaken and made accessible on the web through the online survey: *Awareness of the Universe* at www.hkr.se/AER (Username: galaxy, no Password). The data obtained for the case study reported on at the time of the ESERA 2011 conference was collected from some 34 participants from universities in both Sweden and the USA: 23 learners form across the Swedish university spectrum (Introductory astronomy, Astrobiology, Second year undergraduate physics learners, and Ph.D. students), and 11 experts from both Swedish and US university settings.

The participants were shown video clips extracted from the Flight to the Virgo Cluster simulation and where asked to reflect on what they had seen by answering the following questions:

Watch this clip and answer the questions below! Please answer the questions in order of appearance, using numbers. If you have not noticed something new, feel free to say so.

1) Please write what comes to mind when you watch this clip, like things you noticed, sudden new realizations or connections, surprising or confusing things.

2) What, if any, "I wonder..." questions did this clip raise for you?

The video clips were obtained by clipping a piece of the video into seven short logically holistic sections, lasting on average 15 seconds, and stopping the video at these points to allow for the participants to write down aspects of their reflective awareness which were related to each video clip (just watched).

After the seven clips were viewed and the accompanying questions answered, five follow up questions were asked so as to ascertain, for example, whether they knew where the journey started/ended and things what particularly caught their attention in the movie as a whole.

These written reflective descriptions were coded and sorted into constructed categories, using a constant comparison approach (Strauss and Corbin, 1998; Gibbs, 2002). In other words, the categories were not pre-defined, but rather emerged from the data.

Results and discussion

The analysis of the on-line survey showed that learners' reflective descriptions were markedly different from those of the experts. In terms of the nature of awareness associated with the array of representations that made up the clips of video used for the study, shape, colour and 3-dimensionality were the most prominent in the constituting of conceptualizations in the reflective descriptions. In particular, the representations embedded in 3D generated a clear dimension of "noticing things in new ways", which collectively we characterized as "progressive layers of discernment". When comparing and contrasting learners and experts the profile of awareness categories differed as follows:

Learners: Orion, constellation, perspective, 3D, scale, gas blobs, nebulae, galaxy, colours, speed, structure, the Milky Way, etc.

Experts: Orion, constellation, perspective, 3D, scale, emission nebulae, reflection nebulae, absorption nebulae, stellar nurseries, time, speed, the Milky Way, other galaxies, distribution of stars, stars, star formation, stellar evolution, exoplanets, gravity, star clusters, excitation and de-excitation, HI and HII regions, parallax, etc.

These results are summarized in graphical form in **Figure 2** in terms of learner academic level and the average number of awareness categories that were identified in the video answers provided by the participants.

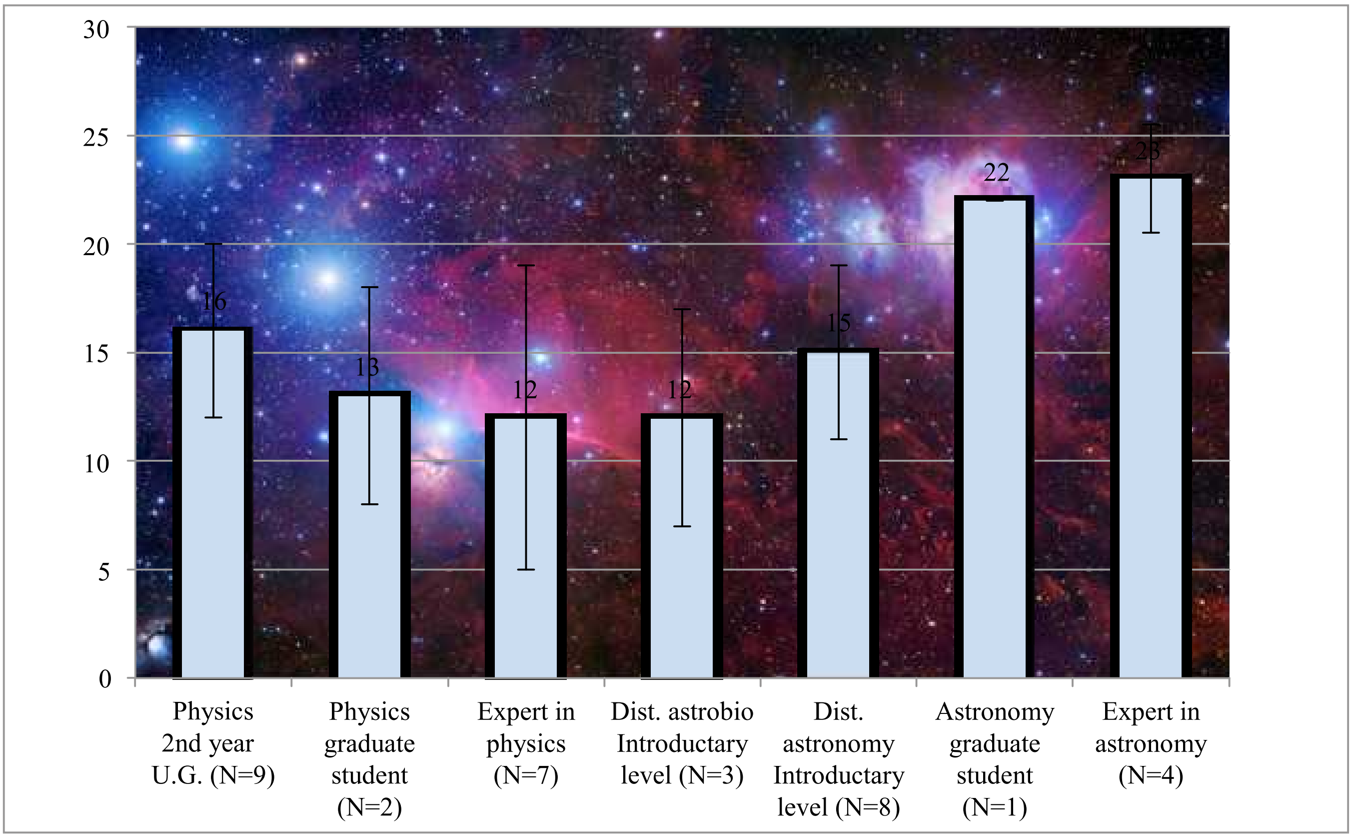

Figure 2 The preliminary results from the study, where the different groups of learners' are plotted on the horizontal axis in academic progression order/subject versus the number of used categories on the vertical axis. The heights of the bars are the average number of categories that we have identified for each group with N=x participants. The error bars are the standard deviations, or, if the number of participants in a group is too low it is the actual spread.

There were also clearly discernable differences between learners from the astrobiology course and learners from the astronomy course. The astrobiology-course learners awareness was grounded much more in esoteric descriptive items such as exoplanets, search for extra terrestrial life, space travel, and shining fog. On the other hand, the astronomy-course learners profile was very similar to that of their general physics counterparts in terms of the number of awareness categories that they used in their descriptions. However, the actual categories did not overlap nearly as well. The physics learners tended to use categories common to a more general physics realm, such as gravity, force, emission lines from different elements (H and He), and the colours of nebulae emanating from different elements and different atomic levels and transitions.

Perhaps the most intriguing result is that across all categories of learners the following categories of awareness were common:

- The experience of 3D -- new *2D-3D awareness*
  Many learners have not experienced the universe as a 3D space; they rather see the Universe in 2D terms, but the simulation gave them insight into the real structure of the universe.
- New *perspective awareness*
  The learners are surprised by the experience of the awareness of new perspectives. For example, noticing how the individual stars in the Orion constellation are at quite different distances from Earth, or seeing a structural view of Orion close up and then passing through.

- The enormous distances between stars and other structures in the galaxy -- the New *scale awareness*
  The learners' answers revealed the difficulties that they had had in appreciating the enormous distances between structures and components of the universe, such as stars, nebulae, star clusters and galaxies.
- New *Time awareness*
  This is an awareness that many learners struggle with in the sense that they do not realise that the Universe they see from Earth does not necessarily look anything like the Universe seen from other places. Because of the limitations that the speed of light introduces to the visual appearance of moving objects, the "actual Universe" is different from what one is able to see from Earth. However, in the simulation, the speed of travel is not related to the passing of time. The learners do not recognise this as being problematic, but they do appreciate that such a journey would take a very long time to actually undertake. On the other hand, the experts often pointed out that the video-presented journey would take too long for it to be possible for a person to experience in real life, and also that time affects the way the universe gets seen.

Conclusions and Implications

Our study is situated in astronomy education research and focuses mainly on the awareness challenges university level astronomy learners' face when trying to create an appropriate visualization of the Universe – that is, in becoming focally aware of the fundamental components, structure, and interactive dynamics of our Universe. By using a realistic video, presenting the Milky Way through a virtual journey, the learners' are given a realistic opportunity to build a 3D, or even 4D (3D + time) picture of the Universe in their minds.

The number of new things that learners need to be able to bring into focal awareness from simulations that deals with properties, structures and interaction dynamics are enormous. To attain an appropriately appreciative understanding means learning to see new things and how to work with them in the context of a given observation. In doing the data analysis we saw how learners may quickly attain new awareness that underpins a deeper understanding of the structure and components of the Universe. This is an indication of the nature of representation affordance that can be evoked by a good simulation, such as the one used in our study, and how important it is for teachers to better understand this learning experience.

Acknowledgement

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THE EFFECTS OF AIM-GAPPED EXPERIMENTATION on CONCEPT LEARNING AND GAINING SCIENTIFIC PROCESS SKILLS

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Abstract: This study was conducted to see the effects of aim-gapped experimentation on concept learning and gaining scientific process skills for middle school students. Aim-gapped experimentation is a new experiment technique, which keeps the curiosity alive in students, contributes to meaningful learning instead of just verifying a scientific truth and can be done in a short time (Güven & Gürdal, 2010). The new experiment technique that is "aim-gapped experimentation" is built on ideas derived from information-gap theory (Lowenstein, 1994; cited in Dijk & Zeelenberg, 2007). In this study, Aim-gapped experimentation is defined and the effects of the aim-gapped experimentation to the concept learning and scientific process skills of 7th grade students in "Light Unit" is tested. At the end of the research, teaching with aim-gapped experimentation was found to be a technique having a positive effect on concept learning and gaining scientific process skills.

Keywords: Aim-gapped experimentation, information-gap theory, science education

INTRODUCTION

As an effective method for over a century laboratory had been given a central and distinctive role in science education (Hofstein & Lunetta, 2003). The role of laboratory is to be a bridge between the intangible world of ideas and thoughts and the concrete world of physical reality (Jone & Lewis, 1978, p:4-5). Pratical work- activities in which the students manipulate and observe real objects and materials is often seen by teachers and others (particularly scientists) as central to the appeal and effectiveness of science education (Abraham & Millar, 2008). The effectiveness of the practical work as a teaching and learning method in school science is being critized in literature (Abraham & Millar, 2008; Hoffstein, 1988). Laboratory activities are categorized variously. The type of categorization as "open ended" and "expository" which is very common in literature is done according to the problem, procedure and outcome of the experiment are given or not (Millar, Marechal&Tiberghien, 1999, p.35). In expository experiments students follow given instructions, and the outcome is predetermined. In open-ended experiments the problem may have multiple solutions, procedure is student generated and the outcome is undetermined. In literature "cook book type" experiments are questioned in terms of the meaningful learning (Hofstein, 1988). Aim-gapped experimentation is defined by Güven & Gürdal (2010) and is built on ideas derived from information-gap theory (Lowenstein, 1994; cited in Dijk & Zeelenberg, 2007). Loewenstein defines "curiosity" as "the desire to know." Loewenstein's "information-gap theory views curiosity as resulting from a gap in one's knowledge". Loewenstein, argued that situational determinants may intensify curiosity and curiosity may be positively related to the knowledge we already have. According to Loewenstein the more we know, the more curious we are about what we do not know (Güven & Gürdal, 2010). Aim-gapped experimentation technique is based on the idea of that curiosity leads to better learning (Engel, 2006). In aim-gapped experimentation there are some gaps in laboratory sheets. These gaps make the students curious about the experiment which they will perform. Aim-gapped experimentation makes use of both open-ended and expository experimentation techniques. In aim-gapped experimentation technique, experiment name and procedure are given as in the case of expository experiments; on the other hand, students are expected to find the outcome themselves as in the case of open-ended experiments. (Güven & Gürdal, 2010). Aim-gapped experimentation technique corresponds with information-gap theory. Everything about experiment is not given, an unknown part is being, but some knowledge (exp: procedure) about experiment is given. By that, a gap (aim and outcome) is formed and the curiosity of student is strived to be high. In aim-gapped experimentation experiment sheets are given before they perform laboratory. These sheets are different from expository experiments' sheets. In these sheets the name of the experiment is given as having no clue about the aim of the experiment. The aim of the experiment is not written in the sheet. There is a gap in here. The sheet has procedure and some router questions. At the end of the sheet there is a gap and asks the outcome of the experiment. After writing the outcome students asked to estimate the aim of the experiment and write it to the gap in the sheet.

If the three experiment techniques (expository, open-ended and aim-gapped) are explained on behalf of information-gap theory the result is like that: There is information but not gap, in expository experiment technique. In open-ended experiment technique there is much more gap according to information. In aim-gapped experimentation technique there is much more information according to gap (Güven & Gürdal, 2010). This relation is given in table below:

Table 1:Experiment techniques with respect to information-gap theory

EXPERIMENT TECHNIQUES	INFORMATION	GAP
Expository experiments	▪ Apparatus ▪ Name of the experiment ▪ Aim of the experiment ▪ Procedure ▪ Outcome of the experiment	
Aim-gapped experiments	▪ Apparatus ▪ Name of the experiment ▪ Procedure ▪ Router questions ▪ Tables for data collection	▪ Aim of the experiment (problem) ▪ Outcome of the experiment
Open-ended experiments	▪ Apparatus ▪ Problem	▪ Name of the experiment ▪ Procedure ▪ Outcome of the experiment

As seen on table above, everything is given in expository experiments. In open ended experiments, the rate of information according to gap is very small. For aim-gapped experiments, the rate of given information acoording to gap is bigger (Güven & Gürdal, 2010).

PURPOSE OF THE STUDY

The purpose of this study was to test the effectiveness of aim-gapped experimentation on concept learning and gaining of scientific process skills. The main research question of this study is "Is there any significant effect of teaching 7th grade "Light Unit" in lessons in Turkey which are planned with aim-gapped experiments on concept learning and gaining scientific process skills?".

METHOD

This study was carried out by using experimental design, consisting of pre-test and post-test including a control group. The sample of the study is composed of totally 76 students from an elementary school in Istanbul, in the second semester of 2006-2007 education year. Participants of the study were 7th grade students from two different classes. The same teacher taught the science and technology lessons in the two classes.

In the control group, lessons were planned by the teacher according to the student expectations of 7th grade “Light Unit” of 2005 Science and Technology Program (TTKB, 2006). The teacher did the lessons with rich methods and techniques, as it should be according to the “2005 Science and Technology Program” requirements. For that he used many different methods in addition to experiments like; observation, question-answer, direct explaining method, taking notes, student book activities, visual materials, problem solving, analogy, role play, brainstorming, models, examples from daily life, watching video and homeworks. In the control group students did expository experiments. The sheets of the experiments were given them in the textbook.

The lessons for “Light Unit” in the 7th grade 2005 Science and Technology Program were replanned for the experimental group. The experiments for the “Light Unit” in the 7th grade science and technology textbook which were done in the control group were reprepared according to “aim-gapped experimentation technique”. This technique is differing from expository laboratory experiments, in that the students were not given the aim and the outcome of the experiment. The sheets were given to the students before the lessons. This group of students were divided into 2-3 students groups and all groups did the experiments by following the new experiment sheets. Students were made to write laboratory reports at the end of the experiments. In this group just the experiments were done differently, the rich teaching methods were also used as in the case of the control group. The importance of doing experiments with small groups, writing individual laboratory reports and making the curiosity of students alive were considered in the experimental group. To make the curiosity alive, aim-gapped experiments were used. Aim-gapped experiments are welded from the researcher’s master thesis in which she introduced the “experiments that the aims are not given” (Güven, 2001). Researcher presented the results of the effects of “experiments that the aims are not given” on student success first in the “88th Canadian Chemistry Conference and Exhibition” in Canada (Güven & Gürdal, 2005). Aim-gapped experimentation is built on ideas derived from information-gap theory (Lowenstein, 1994; cited in Dijk & Zeelenberg, 2007). Aim-gapped experiments are formed by mixing the expository and open-ended experiment methods (Güven & Gürdal, 2010). In this research, totally nine experiments were done by the students. The experiment sheets were given to the students like the case in expository experiments. For these experiments’ which were done in the control group new experiment sheets were prepared. In these sheets some gaps were formed just like the case in open-ended experiments. In the experiment sheets the aim of the experiment was not given. The experiments were same as the control groups’ but in the experimental group the names of the experiments were defined again that included no clue about the aim of the experiment. The procedure was given but the outcome of the experiment was not given with the experiment sheets. There were a few router questions in the sheets to make the students write the observations and the results of the experiments. At the end of the experiment, students were made to write the aim of the experiment and for evaluation they wrote experiment reports.

Instrument and Data Analysis

The researcher aimed to test the effectiveness of the “aim-gapped experimentation technique” in the light of the concept learning and gaining scientific process skills. “Open-ended

Questions" (OEQ) and "Problem-Hypotesis Determination Test" (PHDT) were used to determine the students' level of gaining the scientific process skills. OEQ is composed of 8 questions. These questions were prepared by the researcher, taking into account the unit and the target concepts. The content validity of OEQ was based on an expert opinion and 2 science and technology teachers. After the application of OEQ students answers are marked and the points divided into 3 levels: 1st level: Students did not give any answer or had misconceptions in answer (did not comprehended); 2nd level: Students answers were partly correct. There are some missing concepts (comprehended but there are missing concepts);3rd level : Students answers are correct. (Comprehended).

It was aimed to determine the scientific process skills of students to what extent they could gain. Instead of focusing on all scientific process skills "the problem identification", "hypothesis-building" and "identifying the variables (dependent and independent)" (Aktamıs and Ergin, 2007) skills were tested. "Problem-Hypotesis Determination Test" (PHDT) was created in order to measure the skills with 4 different questions. The content validity of PHDT was based on an expert opinion and 2 science and technology teachers. After the application of PHDT students answers are marked out of 100 points (25 points for each question) and the points divided into 3 levels for problem determination and hypotesis building and 2 levels for variables identification. Problem determination: 1-2 points (did'nt comprehend) 3-5 points (partly compreheded) 6-7 points comprehended; hypotesis building: 1-2 points (did'nt comprehend) 3-5 points (partly compreheded) 6-7 points comprehended; independent variable identification: 1-3 points (did'nt comprehend) and 4-6 points comprehended; dependent variable identification: 1-3 points (did'nt comprehend) and 4-6 points comprehended.

OEQ and PHDT were applied to both groups (control and experimental) as pre-test before the instruction and as post-test after the instruction. To compare the results of post-tests of control group and experimental group independent variable "t" test was conducted with SPSS 11.0 program.

RESULTS

OEQ was applied before and after the implementation as pretest and posttest. After the detailed analysis of pretests of both groups answers' it was seen that both groups answers were incorrect; so it was concluded that both groups' students had not enough pre information about the unit of "Light". The data obtained from the post tests was assessed by using SPSS program. Analysis of the quantitative data is given in the table below.

Table 2: Post-test Results of OEQ

Question number	*Group*	*Test*	*N*	*Mean*	*SD*	**Independent Samples t-test**		
						df	t	P
1st question	Control Group	Post-test	36	4,00	3,69	74	-3,22	<0,01
	Experimental Group		40	6,73	3,67			
2nd question	Control Group	Post-test	36	5,44	3,03	74	0,019	<0,05
	Experimental Group		40	7,55	4,42			
3rd question	Control Group	Post-test	36	2,03	2,72	74	-3,86	<0,01
	Experimental Group		40	5,58	4,87			
4th question	Control Group	Post-test	36	4,50	3,96	74	-0,326	0,597

	Experimental Group		40	5,02	4,59			
5th question	Control Group	Post-test	36	2,69	2,81	74	-2,40	<0,05
	Experimental Group		40	4,30	3,00			
6th question	Control Group	Post-test	36	7,17	3,91	74	-2,86	<0,01
	Experimental Group		40	10,03	3,12			
7th question	Control Group	Post-test	36	2,61	3,23	74	-3,51	<0,01
	Experimental Group		40	5,78	4,46			

Independent t-test was conducted to see if there was a significant difference between the post-test scores of OEQ of the control and experimental groups. According to these results there are statistically significant differences on behalf of the experimental group in 1^{st}, 2^{nd}, 3^{rd}, 5^{th},6^{th}, and 7^{th} questions. In the 4^{th} question there is no significant difference between the post-test scores of OEQ of the control and experimental groups. The results of post test scores of 8^{th} question for both groups were almost equal. So, independent samples t-test were not carried out for this question. The results of OEQ are more likely on behalf of the experimental group. In six out of eight questions experimental group did well according to the control group. This means that doing aim-gapped experiments with small groups has a significantly important effect on concept learning.

The results of the evaluation of the PHDT for the successes of "problem determination", "hypothesis determination", "dependent variable determination" and "independent variable determination" are visualized with graphics in below:

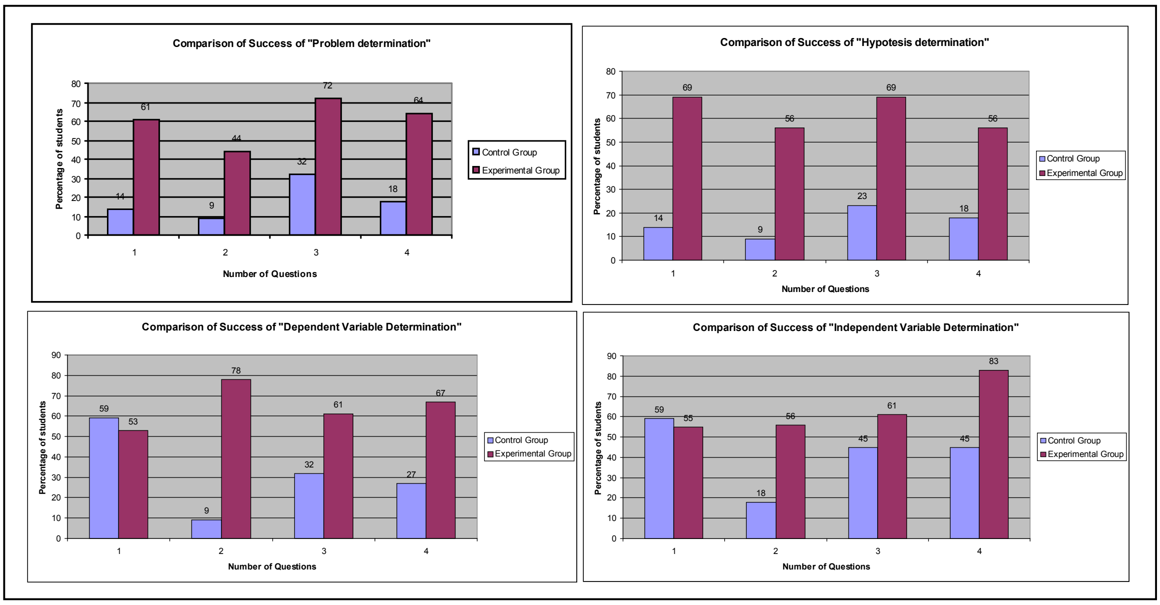

Figure 1: Comparison of percentages of problem, hypotesis, dependent and independent variables determination scores of control and experimental groups

According to the comparison of percentages of problem, hypotesis, dependent and independent variables determination scores of control and experimental groups it can be concluded that the gaining level of scientific process skills of experimental group is statistically different from the control groups'. The students in experimental group were better in determining the scientific processes.

Table 3: Post-test Results of PHVDT

Question number	*Group*	*Test*	*N*	*Mean*	*SD*	Independent Samples t-test		
						df	t	P
1st question	Control Group	Post-test	31	9,13	6,71	65	-3,02	<0,01
	Experimental Group		36	15,64	7,74			
2nd question	Control Group	Post-test	31	6,19	5,73	65	-5,73	<0,01
	Experimental Group		36	16,58	8,58			
3rd question	Control Group	Post-test	31	9,00	7,71	65	-3,56	<0,01
	Experimental Group		36	16,64	9,57			
4th question	Control Group	Post-test	31	6,71	9,26	65	-4,76	<0,01
	Experimental Group		36	17,31	8,94			

To compare the results of post-tests' means bof control group and experimental group for PHDT independent variable "t" test was conducted with SPSS 11.0 program. According to the results it can be seen that the gaining level of scientific process skills of experimental group is statistically different from the control groups'. The students in experimental group were better in determining the scientific processes.

CONCLUSION AND IMPLICATIONS

In literature cook-book type experiments were criticized (Hoffstein, 1988) and science educators draw attention to the importance of seeking new trials (Anders at all, 2003). In this study it is tried to give a respond to the need of alternative laboratory techniques. For that, aim-gapped experiments were performed by small groups and students wrote experiment reports for evaluation. At the end of the study it was seen that aim-gapped experimentation has positive effects on concept learning and teaching scientific process skills. In aim-gapped experiments students learn through the process not just through the results (Güven & Gürdal, 2010). Thus, the experiment sheets which were given to students before the experiments were informational sheets with some gaps in them and they were not just like recipes. The students in the experimental group followed up the new sheets curiously during the experiments. They were much more curious about the experiment according to the control group. Priemer (2006) indicates that successfull students in science don't prefer expository experiments. Open-ended experiements are also not very useful for science lessons because of limited duration of science lessons and crowded classes. As Abrahams and Millar (2008) staded in their recent research the teachers who use "recipe style" tasks explain this as having insufficient time for more open and unstructured manner tasks. To acquire the scientific process skills with traditional methods is very difficult. Practical work should be used by teachers to teach the scientific process skills to their students. As Temiz (2001) states, the teachers have problems with the student's of gaining the scientific process skills in the learning enviroments which they organize in traditional methods. Aim-gapped experiments are useful to improve scientific process skills of sudents. Aim-gapped experimentation technique is useful because it make students curious, is not not like just "recipe style", is suitable for crowded classes and does'nt require much time. As a suggestion aim-gapped experiments should take place as practical work in school science lessons.

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THE INFLUENCE OF CONTENT AND LANGUAGE INTEGRATED LEARNING ON CONTENT PERFORMANCE IN MAGNETISM

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Abstract: Content and Language Integrated Learning (CLIL) is a bilingual teaching method, where content area subjects are taught with a foreign language as a medium of instruction while the first-language plays no or only a very subordinate role. As reaction to a moderate output of foreign language teaching, the Austrian Ministry of Education introduced this concept in the mid 1990s. Compared to conventional bilingual school programmes, CLIL is a flexible concept that can be used in all non language subjects, in all school forms on the secondary level. Positive effects of CLIL on second-language learning have been shown in numerous empirical studies. On the contrary, little is known about the influence of CLIL on students' content performance in general. For the subject physics, a first step in investigating CLIL's effect on content achievement was made by a field study. The investigation was based on a pre- and post-test design. The population consisted of 205 grade 11 students, from 6 different Austrian High Schools. Based on a control-group design, students were instructed in magnetism either in their first language (control-group) or in English (test-group). Students' subject knowledge in the field of magnetism was tested in both groups before and after the instruction with an assessment tool developed for this study. According to the analysis of data obtained, differences between both groups' subject achievement could not be observed.

Keywords: language integration, magnetism, comparative study,

1. INTRODUCTION

Content and Language Integrated Learning (CLIL) is a bilingual teaching method, where content area subjects are taught with a foreign language as a medium of instruction while the first-language plays no or only a very subordinate role.

As a reaction to advancing globalization and moderate output of language teaching, especially in the domain of communicative competence, the Austrian Ministry of Education introduced this concept in the mid 1990s. The two main objectives, followed by launching CLIL were first to improve foreign language education and second to deepen intercultural learning (BM:BWK 2008).

Compared to conventional bilingual school programmes, which have played a subordinate role in the Austrian education landscape, CLIL is a flexible concept. It can be used in all non language subjects in all school forms on secondary level and its intensity can range from teaching isolated topics in one subject to courses lasting for a school year in one or more subjects (Abuja & Heindler 1998).

So far the CLIL-concept has been introduced by many schools in German speaking countries. The number of schools applying this bilingual teaching method in one or more subjects or conducting CLIL-projects is still increasing. Science is, however, poorly represented among the subjects using a content and language learning approach. The two main reasons for this situation are that science teachers feel in many cases not confident enough in their second language, many teachers are concerned about the impact of CLIL on their students' achievement.

Evaluating the output of CLIL, two different domains are relevant: the aspect of second-language learning and that of content learning. As far as students' achievement in second-language learning is concerned, quite a number of empirical studies have proved that CLIL offers linguistic advantages. CLIL students generally outperform students conventionally instructed in English in the domain of communicative competence (Wesche 2002). They possess a significantly larger passive and active range of vocabulary and are more fluent (Dalton-Puffer 2008).

On the other hand, the subject specific effectiveness of CLIL is discussed on the basis of beliefs of current teaching practice rather than on empirically proved arguments. Here ideas, like the influence of CLIL on subject related motivation or its contribution to a deeper subject understanding due to deeper information processing are propagated (Koch & Buender 2006; Bonnet 2004).

What we know from research shows a different picture. Although, several evaluations classify CLIL as successful on the level of content-achievement, a closer examination of these results reveals weak spots like small samples and non-standardized procedures of evaluation (comparison of grades or self-evaluation). So far hardly any attempts have been made to replicate these results with standardized knowledge tests or concept inventories. In addition, the majority of investigations was carried out in subjects most frequently using a content and language integrated approach, like history or geography (Hollenweger et al. 2005). Here the question arises, whether results concerning CLIL's influence on content achievement can be transferred between two subjects emerging from different epistemological traditions (e.g. history and physics).

All in all, little is known about the influence of CLIL on content achievement in physics so far. As a starting point, a study (Author 2005) comparing the performance of students instructed either with a content and language integrated approach in English or in their first language German, was carried out for the topic of magnetism in grade 11.

The main research questions of this field study "Introduction into Magnetism" focused on effects of CLIL on content-achievement, gender performance and lesson communication.

2. METHODS

The investigation was based on a pre and post-test design, with test and control group. The population consisted of 205 Year 11 students from 6 different Austrian High Schools. The 11 classes selected did not have any experience with content and language integrated instructional approaches.78 students were instructed in their first-language (control group, CG) and 127 in English as working language (test group, TG).

For the treatment an instructional arrangement of four lessons on introductory magnetism was developed, based on methodological guidelines deriving from literature on CLIL (Thuermann 2002; Wildhage & Otten 2003; Zydatiß 2010).

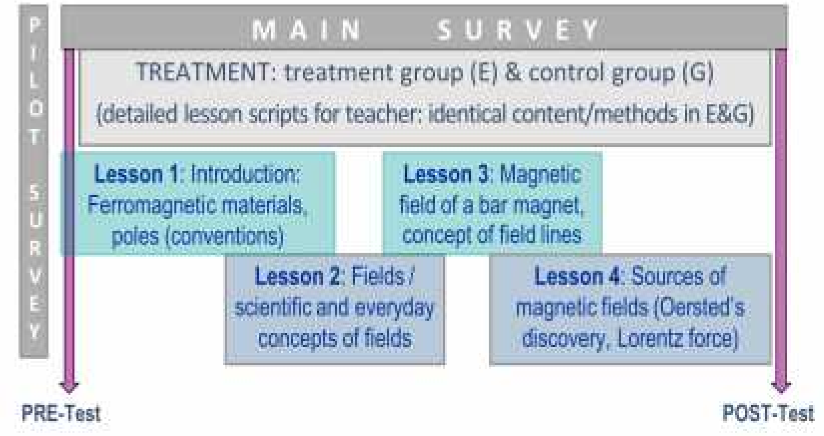

Figure 1: Research Design

Detailed lesson scripts including didactic, methodical and content related guidelines were provided for all teachers. The materials made available for teachers of both groups differed only in the language used; the content treated and teaching methods used were identical.

Since test instruments available for magnetism did not meet the needs for this study, an assessment tool, measuring students' content knowledge in the subarea of magnetism treated, was developed.

The knowledge test consisted of 21 items (6 scales) in the pre-test version (α=0.716) and of 27 items (8 scales) in the post-test version (α=0.775). Non cognitive items of the test focused on lesson communication and on personal data.

3. RESULTS

The analysis of data indicates that the language of instruction did not have much influence on the content achievement. The subject related performance of both groups was analyzed in two categories: students' self evaluation was checked and at the same time, measurements were taken by the knowledge test developed for this study. The comparison of pre-test and post-test data of students' self evaluated learning effects showed moderate to big effects for the test group (d=0.7) and for the control group (d=0.81).

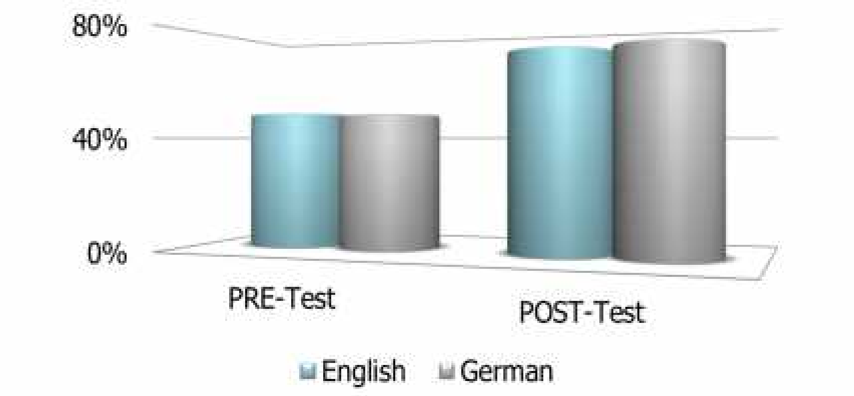

Figure 2: Subject related performance in pre- and post-knowledge test for test group (English) and control group (German)

The results of the knowledge test confirm these subjective impressions about the treatment. Learning effects achieved by the interventions in both groups are medium for both languages of instruction ($d_{testgroup}$=0.602; $d_{controlgroup}$=0.640). Statistical analysis also proves, that there is no significant difference between test and control group.

The gender analyses of the knowledge test also shows the well known effect that male students perform significantly better than female students. Achievement gains in the post-test showed, however, a small advantage for female students of both groups.

Further results were obtained concerning the effects CLIL had on the lesson communication. The majority of students experienced a balance between positive and negative effects, although these students had not had any CLIL experience before.

4. CONCLUSIONS AND IMPLICATIONS

The status of research on content and language integrated learning approaches (in physics) can be summarized as follows: while language learning advantages are already empirically proved, the influence of CLIL on content-achievement is at the very beginning. The study presented in this paper may be seen as a first step. The field study on magnetism shows that CLIL can be as successful as instruction in the first-language in terms of content-achievement. Although the test group did not have any experiences with content and language integrated learning before, they did equally well in the knowledge test. However, these results cannot be generalized for the effect of CLIL on content-achievement in physics, since they were achieved in a certain age group and with a certain topic.

As far as gender is concerned the relative gain in content knowledge is rather equally distributed among sexes. This might be a hint that CLIL can provide a learning environment quite equivalent in terms of gender.

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GRAPHS IN UPPER SECONDARY SCHOOL CHEMISTRY EDUCATION

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Abstract : Graphs are important in elucidating chemical concepts. The present study determines the role of graphs in upper secondary school chemistry education in Finland by analyzing chemistry textbooks. The employed research method is content analysis. Three upper secondary school chemistry textbook series, 15 books in total, were randomly selected as research material. The research was guided by following questions: 1. How many graphs are there in upper secondary school chemistry textbooks?, 2. Where are the graphs located in textual context?, 3. How are they presented?, and 4. In teaching of which chemical concepts are they used? The results suggest that graphs have a very central role in upper secondary school chemistry education. The total number of graphs was high in text (N=116) as well as in tasks (N=66), and in draw a graph exercises (N=50). Most of the graphs were located within the body text. The graphs were used to illustrate several chemical concepts and phenomena. The most common use of graphs was in visualizing reaction energy and reaction kinetics.

THEORETICAL BACKGROUND

Graphs have been important tools in natural sciences ever since they were invented in the 16th Century. Graph was invented to help in perceiving the connections between different quantities. It can be described as a cultural tool – interpreting graphs requires cultural background knowledge (Vygotski, 1979). Some difficulties in learning natural scientific subjects can be related to poor graphic literacy that hinders the ability to apply mathematics to natural sciences (Tversky, 2002). Graphical abilities are a combination of three different elements: a) interpretation, the ability to transform a graph into written text, b) modeling, the ability to produce graphs from the experiments, c) transforming, the ability to produce multiple different graphs from the same experiment (Kwon, 2002).

Learning from graphs is noted to be challenging for students in many contexts of natural sciences, because it requires examining multiple concepts simultaneously (Orton & Roper, 2000). Students may have conceptual difficulties in understanding the graphs (Atar, 2002; Friedler, Nachimias & Linn, 1990). The previous studies have shown that students have difficulties in identifying the graph and choosing between the x-axis and y-axis (Aksela, 2005).

The basic knowledge of graphs is usually gained in mathematics courses. In Finland, the use of graphs in high school chemistry education is mentioned in the National Core Curriculum (The Finnish National Board of Education, 2003) as a focal objective only in examining phenomena relating to chemical equilibrium through experimentation and by using models. The transfer of learning from one subject to another requires contexts that cross the borders between the subjects (Rauste-von Wright & von Wright 1994). Textbooks have a central role in chemistry education, and they are used as reference in 95% of the teaching (Ahtineva, 2000).

RESEARCH METHOD

The research method of the present study is content analysis. The research was guided by the following questions: 1. How many graphs are there in upper secondary school chemistry textbooks?, 2. Where are the graphs located in the textual context?, 3. How are they presented?, and 4. In teaching of which chemical concepts are they used?

Three chemistry textbook series out of five available ones were randomly selected as research material. The textbooks for chemistry courses 1 to 5 were analyzed from each series. The total number of books was 15. The research was predefined to focus on actual course books that the students use. To determine the reliability of the research, three of the books were selected for reanalysis. The graphs were studied according to 27 absolute variables [(1,0) or (0, 1, 2…)] and one classifying variable (Lodico et al. 2006).

Table 1. Variables in the textbook analysis.

FUNCTION OF VARIABLE	ANALYSED FUNCTION	VARIABLES
Concepts	Classified according to the Finnish National Curriculum	Classifying (1, 2, 3… .20)
Course	Chemistry course number	Absolute (1, 2, 3, 4, 5)
Textbook series	Each series was numbered	Absolute (1, 2, 3)
Main division: location	In task	Absolute (0, 1, 2, 3…) Number N
	Between text	Absolute (0, 1, 2, 3…) Number N
	Aside text chapter	Absolute (0, 1, 2, 3…) Number N
	Extra chapter or text box	Absolute (0, 1, 2, 3…) Number N
	Draw a graph: experimental	Absolute (0, 1, 2, 3…) Number N
	Draw a graph: literature	Absolute (0, 1, 2, 3…) Number N
Tasks:	Draw / fill	Absolute (0, 1)
	Read results	Absolute (0, 1)
	Explain	Absolute (0, 1)
	Analyze / Evaluate	Absolute (0, 1)
	Calculate	Absolute (0, 1)
Explaining the graph	Connection between the axes is explained in the text	Absolute (0, 1)
	Caption	Absolute (0, 1)
	Explanation in the caption	Absolute (0, 1)
	Named properly	Absolute (0, 1)
	Word function connected	Absolute (0, 1)
Pictures	Pictures in the graph	Absolute (0, 1, 2, …) Number N
Axes	Name and / or unit in the x-axis	Absolute (0, 1, 2)

	Numbers in x-axis	Absolute (0, 1)
	Name and / or unit in the y-axis	Absolute (0, 1, 2)
	Numbers in y-axis	Absolute (0,1)
Graphs	Visible points	Absolute (0,1)
	How many curves / graphs in one graphical representation	Absolute (0, 1, 2, 3,….) Number N
	Derivate or slope	Absolute (0,1)
	Integration application or surface area (distribution functions)	Absolute (0,1)

The analysis was done with SPSS-program.

RESULTS

In total, there were 232 graphs or graph tasks in the research material that were included in the analysis. The total number of graphs was 182, out of which 90 were located within the body text, 13 in the side column, 13 in the extra chapters, and 66 in the tasks. In addition, the textbooks included altogether 50 exercises to draw graphs, which were analyzed under the task category. (See Charts 1 and 2.)

Many significant conclusions can be drawn from the data. 43% of the graphs were properly identified. The points were marked to 16% of the graphs. Derivative or integral was not mentioned with any of the graphs. The concept of function was mentioned with 13% of the graphs, but it was used in expressions such as “the function of something”, not as a mathematical entity.

The graphs were used in teaching of nine particular chemical concepts. The most common use of graphs was in visualizing reaction energy (see Chart 2).

Chart 1. The number and location of graphs by the upper secondary school course.

Location of Graphs / Course	Between text chapters	Beside text	In extra-chapter	In task	Draw a graph: practical work	Draw a graph: in text / table	Total (N)	Total (%)
Course 1	7	0	1	2	0	3	13	6
Course 2	19	2	2	14	3	1	41	18
Course 3	35	4	9	18	12	12	90	39
Course 4	0	0	0	3	3	2	8	3
Course 5	29	7	1	29	2	12	80	34
Total (N)	90	13	13	66	20	30	232	100
Total (%)	39	6	6	28	9	13	100	

Chart 2. The frequencies in the use of graphs in teaching of different concepts. *c, m, n, V or x plotted versus time.

Location of graphs Context / Context	Between text chapters	Beside text	In extra-chapter	In task	Draw a graph: practical work	Draw a graph: in text / table	Total (N)	Total (%)
Solubility	4	1	0	7	2	1	15	6
Titration	8	0	1	12	8	2	31	13
Boiling points	5	1	0	4	2	0	12	5
Reaction rate	3	1	3	3	0	8	18	8
c, m, n, V or x plotted versus time	10	2	0	16	7	1	36	16
Reaction energy	25	1	1	8	4	3	42	18
Spectrophotometer	1	0	0	2	1	2	6	3
Other spectra	9	0	2	9	0	0	20	9
Distribution function	7	1	0	1	0	0	9	4
Other graphs	18	6	6	4	6	3	43	19
Total (N)	90	13	13	66	20	30	232	100
Total (%)	39	6	6	28	9	13	100	

CONCLUSIONS

The present study shows that graphs have a focal role in upper secondary school chemistry education in Finland. The number of graphs within the text and in tasks is high. The importance is highlighted by the fact that the graphs are usually located within the body text. In the textbooks for courses 3 and 4, the amount of graphs is so high that insufficient graphic literacy could be reflected in learning. There should be more focus on teaching about graphs during chemistry lessons.

In the data, there was a constant lack of sufficient identifying of the graphs; less than half of them were identified properly. More attention should be paid in the identification as, according to previous studies, students have difficulties in identifying graphs (Aksela, 2005). The research also shows an evident lack of mathematical functions in the background of chemical graphs. The graphs function as visual displays of research results, but their mathematical evaluation is scarce in upper secondary school chemistry, or the results are evaluated from the perspective of one point, not the whole function.

Lines are fitted within the graphs, but instead of placing value on the function, only one point is analyzed. It could be stated that the way upper secondary school students use graphs is similar to drawing connections in the graph without mathematical functions or equations in Galileo Galilei’s time. According to previous studies, the lack of function can make perceiving the graph and interpreting it intuitively more challenging for students (Leinhardt, 1990).

The use of graphs in supporting chemistry teaching requires the students to understand the characteristics of graphs and apply the information the graphs represent to support the learning process. There is a demand for diverse approaches to support learning.

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THE EFFECT OF BRAIN BASED LEARNING ON ACADEMIC SUCCESS, ATTITUDE AND RETRIEVAL OF INFORMATION IN SCIENCE AND TECHNOLOGY CLASSES

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Abstract: The purpose of the study was to examine the effect of Brain-Based Learning approach on achievement, attitude and retention of knowledge in 8th grade students' science and technology classes.

Brain based learning, which focuses on the ways the brain learns best rather than the ways of teaching, with a rich learning environment and trigger of thinkings.

The pre/post-test control group research model was used in this study. The research was conducted with one experimental group and one control group in 2008-2009 academic years. Totally 30 students, participated in this research. The study took place during the teaching of "State of Matter and Heat'' with of the science and technology course. In the experimental group, students were taught according to the brain-based learning approach, while in control group students were taught according to the traditional methods.

The data obtained were analyzed using the SPSS program for Mann Whitney U Test, Friedman Test and Wilcoxon Sign Rank Test. The means and standard deviations were calculated for groups.

The results demonstrated that there was a statistically significant difference on achievement, attitude and retention, conclude of brain-based learning, between the experimental group and the control group, in favor of the experimental group.

Keywords: Brain Based Learning, Science and Technology Teaching, Achievement, Attitude, Retention.

INTRODUCTION:

Brain is a structure inside the skull consisting of more than 100 billion neurons. A neuron transmits a received stimulus to another neuron at a speed higher than 380 km/h. The striking speed of the transmission of stimulus is a feature arising from the closeness of neurons. When volume and mass of the brain is taken into consideration, there are approximately 10 million neurons in each centimeter cube of the brain. İnci (2010) defines brain as an exceptional organ in which countless mysteries are woven and different features of which are explored and written by the ink of time every moment.

While the brain hosts every kind of learning in a unique way, the factor of environment should never be ignored and the question of how the best way of learning can be achieved within a rich life pattern by using various motivation factors and individual's spheres of interest, too.

Brain Based Learning (BBL) is a holistic approach regarding learning with a developmental and socio-cultural perspective based on the structure and functions of the human brain (Caine & Caine,1995). This learning theory is based on the structure and function of the brain research came from advances in neuroscience. Brain Based Learning is a Learning approach that is based on the structure and function of the human brain. Different than traditional methods, brain based learning emphasizes meaningful learning instead of

memorization. Brain-Based Learning takes into consideration a student's brain as a whole when it comes to learning. Often, we look at a student's learning style as the street to educate them. However, there are multiple ways of learning, and each of us might utilize different aspects and areas of our brains in order to process information in the most efficient manner.
Brain-based teaching incorporates three instructional techniques:
*Orchestrated immersion – Creating an educational experience that immerses students in higher-order thinking, making connections relevant, and using creativity to design learning environments. * Relaxed alertness – An atmosphere that is low threat and high challenge. The goal is to eliminate stress and fear that inhibit learning and provide a learning environment that is positive, non-threatening and challenging. *Active processing – Students need time to consolidate and internalize information by actively processing it (Caine, 1997). According to research on brain-based learning, environments, diet, amount of sleep, and water intake all affect the way our brain responds and learns.

Brain-Mind Learning Principles: *All learning is physiological., * The Brain-Mind is social.* The search for meaning is innate. * The search for meaning occurs through patterning. *Emotions are critical to atterning. *6. The Brain-Mind processes parts and wholes simultaneously.*Learning involves both focused attention and peripheral perception.*Learning always involves conscious and unconscious processes. *There are at least two approaches to memory: archiving individual facts or skills or making sense of experience.*Learning is developmental. *Complex learning is enhanced by challenge and inhibited by threat associated with helplessness. *Each brain is uniquely organized (Caine & Caine, 1990).

Brain-Based Learning approach is student-centered. Brain-Based Learning approach could be added to the course which activates the brain of all kinds of element. For example, in science and technology issues could also be utilized from history, geography and philosophy. Students' interest in the subject area is known to be connected directly to that field. According to the students' interest in the subject area may be contacted directly.

Problem Sentence:

Is there a statistically meaningful difference between the Science and Technology class of 8th grade students in primary school regarding “States of Matters and Heat” unit who receive BBL approached and traditional education with regards to level of permanence of success of information and changes in brain dominance? In addition to, sub problems are the following; is there a statistically meaningful difference between points of pre-test, final test and permanence tests of the students in experiment group, was there a change observed in the attitudes of students in experiment and control group towards science before and after the application of BBL method, research is an experimental type of study. Pre-test – final test control group pattern was implemented.

Method:

The pre/post-test control group research model was used in this study. This study was carried out in Elazığ in the second half of 2008-2009 educational years. Work group of the study consists of 8th grade students of Alacakaya Primary School. 30 equivalent students who were chosen among 70 students by equalization participated in the study. Analysis of data was made by a packet program called SPSS 16 for Windows. Friedman, MWU tests with frequency and percentage values were used in the analysis of data.

Data Collection Tools:

Data collection tools are brain dominance tool, achievement test and attitude test. Brain hemispheres have effective roles in different functions.‘Brain dominance’concept is used to express the dominance of one hemisphere of brain to the other in some specific function. Brain dominance tool, Davis and others (1994) adopted by the tool. The original of tool; 39 items and each item the right hemisphere of the brain, the left hemisphere and both used the equal dominance, contains three options. We used the form translated to Turkish of Davis's Brain dominance tool. This tool consists of 26 items. The validity and reliability study of the Turkish version of Brain dominance tool was conducted by Avcı (2006), 200 primary 7th grade student on the applied and the reliability coefficient is calculated as 0,70. In the evaluation of the brain dominance tool utilized from the ranges of values and definitions Mariani (1996)'s used, an evaluation criteria schedule is constructed.

Steps in the evaluation of brain dominance tool are as follows;

In evaluation of items, (-) sign is put in front of 'A' option, (+) sign is put in front of 'B' option. Any signs are put in front of 'C' option. According to the scores between -26 and 26, judgements are made about students' which brain hemisphere more work. Students' brain dominances are found out according to the following number ranges and definitions:
*Range from -26 to -21: Left Brain Dominance (very strong), *Range from -20 to -15: Left-brain Dominance, *Range from -8 to -14: Left Brain Dominance (More Dominant), *Range from -7 and -1 range: Left Brain Dominance (Less dominant), *0: The two sides of the brain the same dominant (The same dominance), *Range from +1 through +7 range: Right Brain Dominance (Less dominant), *Range from +8 to +14 range: Right- Brain Dominance (More Dominant), *Range from +15 to +20 range:Right-Brain Dominance, *Range from +26 to +21 range: Right- Brain Dominance (very strong).

A pilot application was made in order to assess the impact of data collection tools on students and the level of clearness and understandability of the study and if it serves its purpose. Another purpose of this pilot application is to increase the validity and credibility of the study. In this context, unit of "States of Matter and Heat" was covered with materials prepared in compliance with BBL. Posters, formulas and rules written on colorful balloons, various laboratory tools and devices to be used during the class and audio visual recording devices were prepared before class according to the quality of the subject to be learnt. With some students, the clips filmed outside the classroom.

For the achievement test 22 multiple choice questions were prepared about the unit of "States of Matter and Heat". Questions were prepared by the researcher based on the textbooks and activity books of Ministry of Education (MEB in Turkey) used in 8th grade. Alpha credibility coefficient of the test was calculated as 0.84, average difficulty was calculated as 0.73 and average distinguishing capacity was calculated as 0.45 as a result of analyses. Achievement test as implemented as pre-test, final test and permanence test to experiment and control group students.

As most of the experiment group students use their left brain, objects to activate the right brain were chosen during preparation process of the class, however left brain was not neglected. For instance, students were sometimes asked to close their eyes and imagine or to draw a picture or a caricature about the subject during the class. As a result of in class observations, it was seen that even some students who try to disguise behind the lie of "I don't understand" start to develop a salient interest and desire to learn.

Short videos (clips) were shot in which students took part specifying the important parts in text and activity books regarding the unit of "States of Matter and Heat" while covering the subject with BBL method. Experiment group students watched this video at regular intervals and it was found out that their interest in the lesson increased in a positive way. These clips helped students in understanding the topic. By using of popular music in clips, were lyrics changed (were adapted to science and technology). So, the course content objects were presented in an entertaining way with video-clips in certain periods. Thus, it was provided that the subject took place in their minds in a more efficient way.

Findings derived from the study are restricted with the data derived from the students attending classes 8-A and 8-B in Alacakaya Primary School in Elazığ during 2008-2009 educational years, Science and Technology lesson's unit of "States of Matter and Heat" as well as tests prepared by the researcher and brain's dominance tool. In order to determine the equivalence of the groups, the averages scores of the students in both groups have been compared with the personal information questionnaire and science and technology school report scores of the groups have been taken into consideration.

FINDINGS:

Brain dominance instrument to the experiment group students was applied before and after the experimental process. The purpose of a supply of experimental post-process, students' brain dominance BBL method to discover whether there really is causing a change. The levels of brain dominance of the students in experiment group is usually left brain dominant (before the experimental process). There are left brain dominance (less dominant) students are %73, the two sides of the brain the same dominant students are %7, right brain dominance (less dominant) students are %20, according the evaluation (Brain dominance tool scores of the students in experiment group). Seven students' have been changes in the brain dominance after the application BBL (Table 1).

Table 1: Those who change in the brain dominance after the application BBL

Before the application BBL	**Evaluation**	**After the application BBL**	**Evaluation**	**Those who change in the brain dominance**
-3	Left brain less dominant	-2	Left brain less dominant	
1	Right brain less dominant	-4	Left brain less dominant	*
-2	Left brain less dominant	2	Right brain less dominant	*
-7	Left brain less dominant	-1	Left brain less dominant	
2	Right brain less dominant	-1	Left brain less dominant	*
7	Right brain less dominant	-3	Left brain less dominant	*
-2	Left brain less dominant	-1	Left brain less dominant	
-3	Left brain less dominant	1	Right brain less dominant	*
-1	Left brain less dominant	4	Right brain less dominant	*
-5	Left brain less dominant	-6	Left brain less dominant	
-4	Left brain less dominant	-2	Left brain less dominant	
-4	Left brain less dominant	-4	Left brain less dominant	
-1	Left brain less dominant	-1	Left brain less dominant	
-2	Left brain less dominant	1	Right brain less dominant	*
0	The two sides of the brain the same dominant	0	The two sides of the brain the same dominant	

The Friedman Test is used to test hypotheses involving several measurements obtained from the same group. Friedman test was applied to experiment group students in order to specify if there is a statistically meaningful difference between their results of pre-test, post-test and permanence tests.

Table 2: The Mean Ranks of the Experimental Group for Pre-test, Post-test and Follow-up Scores of academic achievement tests.

Tests	**n**	**Mean**	**Sd**	**Mean rank**	**X²**	**df**	**p**
Pre test	15	14,8000	2,67795	1,17	18,750	2	,000*
Post test	15	18,8667	1,50555	2,67			
Permanence test	15	17,7333	2,28244	2,17			

According to the results of Friedman test which was applied to reveal if there is an important role of permanence test which was applied for about three months later, final test that was applied just after the lesson and pre-test which was applied before BBL method, a statistically meaningful difference of the points of the achievement tests applied at regular intervals on the permanence of information (X^2 (df=2, n=15)=18.750, p< .05). As a result, it can be concluded that BBL method is efficient in making the information permanent.

Table 3: The Wilcoxon Signed Rank Test as a post-hoc test results

		Wilcoxon Matched Pairs Signed Test			
Post test-Pre test	**n**	**Mean rank**	**Sum of Rank**	**z**	**p**
– Ranks	0	,00	,00	-3,306	,001*
+ Ranks	14	7,50	105,00		
Ties	1				
Total	15				
Post test-follow up test – Ranks	3	5,83	17,50	-1,697	,090
+Ranks	9	6,72	60,50		
Ties	3				
Total	15				
Follow up-Pre test – Ranks	2	4,00	8,00	-2,990	,003*
+Ranks	13	8,62	112,00		
Ties	0				
Total	15				

According to the results of Wilcoxon Signed Rank test which was applied post hoc, the statistically meaningful difference between pre-test and final-test results of experiment group students is (z=-3,306, p< ,05) whereas the difference is (z=-2,990, p< ,05) between the pre-test and the permanence test. However, no statistically meaningful difference was found between the measurements according to the results of Wilcoxon Signed Rank test which was applied post hoc even if Friedman test says that there is a meaningful difference between the points attained from post test-permanence test.

Table 4. The Mean Ranks of the Control Group for Pre-test, Post-test and Follow-up Scores of academic achievement tests.

Tests	**n**	**Mean**	**Sd**	**Mean Rank**	**X²**	**df**	**p**
Pre- test	15	12,8000	2,83347	1,97	,250	2	,882
Post- test	15	12,8667	2,13363	2,10			
Permanence Test	15	12,6000	1,99284	1,93			

According to the results of Friedman test, no statistically meaningful difference was found of the points of achievement tests which were applied to control group students at regular intervals on the permanence of learnt information (x^2 (df=2, n=15)= ,250, p> ,05). As a result, it can be said that traditional methods are not sufficient to ensure the permanence of learnt information.

Table 5. The Mean Ranks of the Experimental and Control Group students for science and technology pre- attitude test score

Mann-Whitney U Test						
Groups	**n**	**Mean Rank**	**Sum of Rank**	**MWU**	**z**	**p**
Experiment Group	15	13,90	208,50	88,500	-1,001	,317
Control Group	15	17,10	256,50			

According to attitude pre-tests which were applied to experiment and control group students before the application of BBL method, there is no salient difference between the attitudes of students towards Science and Technology (U=88,500, p>0,05). Namely, groups were equivalent in their attitudes towards science before the application of BBL method.

Table 6. The Mean Ranks of the Experimental and Control Group students for science and technology post- attitude test score

Mann-Whitney U Test						
Groups	**n**	**Mean Rank**	**Sum of Rank**	**MWU**	**z**	**p**
Experiment Group	15	21,10	316,50	28,500	-3,501	,000*
Control Group	15	9,90	148,50			

Mann Whitney U Test was applied in order to test the hypothesis claiming that there is a statistically meaningful difference between the attitudes and perception levels of students receiving traditional education and students receiving education in accordance with BBL method regarding science after the experimental processes. Accordingly, there is a salient difference between the points of attitudes of students of experiment and control groups toward Science and Technology (U= 28,500; p<0,05). The fact that BBL has changed students' points of view can be mentioned among the reasons of the difference to the advantage of experiment group.

CONCLUSION

Brain is so strong that, it is impossible to talk about something difficult for a properly motivated and programmed brain. As for our imagination, it has no limits. As a matter of fact, inventions of today have come true as a product of some people's imaginations.

Our students are both going to learn without getting bored and take firmer and more confident steps along the path of success in an environment enriched by components to make brain more active.

In our study, it was clearly observed that even the students saying that they don't like science classes took an interest in science. When both teacher and students come to class getting prepared before with various materials and students learn information one to one and interpret by projects and performance homework; therefore different zones of the brain are activated and hormones of happiness are released in brain along with the success accompanied by productivity.

Upbeat or relaxing music was played during the classes. For example songs were composed such as "Gar mı yağmış şu Harput'un başına, Gurban olam toprağına daşına" (Did snow fall down on Harput, May I give my life for its land) (resembling a Turkish folk song) and these songs were adapted to the subject. In addition, ‘’There is a huge difference between heat and temperature...’’ and so on. sentences clips were filmed.

This information can be used in the classroom to create vibrant learning environments. Other suggestions on how to integrate brain-based teaching include: incorporate learning with storytelling. Storytelling is an effective way to ground the meaning in structure and provide for emotion. Provide structure – connect today’s material with previous and future material to help each person as he/she seeks to make sense of the information he/she hears or sees. Speculations, experiments, question and answer sessions, hold debates, games, music, songs are used role playing to embed information into the student’s long-term memory.

Relaxing movements were made when they got bored and they were allowed to bring their needs to the classroom such as water. Among the reasons why students like BBL method, building a comfortable learning environment can be counted. So every object to activate the brain is seen as a tool for the class.

There is a meaningful difference between recalling levels of students of the control group to which traditional teaching methods were applied and experiment group to which BBL approach was applied to the advantage of experiment group in Science and Technology class. Namely, BBL approach is more effective than traditional education in increasing recalling level.

There is a meaningful difference between attitudes of students of the control group towards science to which traditional teaching methods were applied and experiment group to which BBL approach was applied to the advantage of experiment group in Science and Technology class. It can be said that BBL approach is more efficient than traditional education in developing positive attitudes towards science. Obtained results are also parallel with the literature.

At the end of the research, it is revealed that the students who are educated by the Brain-Based Learning method are more successful and have a higher motivation than the students who are educated by the traditional instruction methods. Each brain thinks different. Each brain looks different windows to the world. With different brains in the future to be applied with brain-based learning method not only in the teaching of science, other areas will increase the success and future of education is a fact that more enjoyable

NOTE:

In this study has benefited from the thesis of Nuray İNCİ (2010).

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TEACHERS' CONCEPTIONS: INTERACTION BETWEEN SELF-EPISTEMOLOGY / DIDACTICAL SKILLS / PROFESSIONAL IDENTITY. "MIXTURES AND SOLUTIONS" COURSE DESIGN – ANALYSIS OF FRENCH SCHOOL TEACHERS' PRACTICES IN THE LAST ELEMENTARY GRADES

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Abstract: The actual designing process of three school teachers about "mixtures and solutions" course is analyzed and categorized within a threefold dimension system: scientific/school knowledge epistemology, PCK and teacher professional identity. The "process matrix" thus constructed helps the understanding of the individual methodological process.

Keywords: grade 3–5, teaching process, course design, process matrix, mixtures and solutions.

INTRODUCTION

This presentation relates to ongoing research in the preparation of a thesis in science education. We are interested in the work of teachers in last elementary grades in France and especially in the designing process of teaching sequences about "mixtures and solutions."

This study is obviously motivated by heuristic considerations but also by the concern to produce a theoretical framework that can contribute to the instrumentation of the training of primary schools' teachers. To achieve this goal, we have built a framework to help reflexivity during the designing of lessons. This is to give teachers the possibility to identify and choose the nature and identity of their own teaching approach.

DESCRIPTION, REPRESENTATION AND INTERVENTION PURPOSES

This study aims to describe the nature and identity of the taught knowledges (Lebeaume, 2000) and the nature and identity of the teaching processes as reported by last grades elementary school teachers during the phases of the designing of the courses. It also aims to represent the guidance of the course (Astolfi, 1991), as it appears during the designing process. To do so we intend to characterize the intentions expressed by the teacher as well as the resources (both material and intellectual) he uses. The teachers' conceptions are part of some "self-didactics", individual and contextual. The identification of those conceptions contributes to enlighten the gap that may exist between the principles summoned (teaching and learning) and what the practical implementation process reflects. This is, ultimately, to contribute to the designing of a suitable *didactical space* (Calmettes, 2009) to describe the processes of teaching.

Finally, this study aims to build tools for intervention in initial and continuing training of primary school teachers. These should promote awareness of the nature and identity of individual teaching processes; it should also give the opportunity to discuss the suitability of a given teaching process with a clearly identified didactical intention.

THEORETICAL BACKGROUND

Curricular approaches

We use various general categories related to curriculum studies (Audigier and Crahay, 2006; Forquin, 2005): those related to the development of a formal curriculum (recommended curriculum, written/mandatory curriculum, supported curriculum) as well as those related to the actual activity of teaching (taught curriculum, assessed curriculum, hidden curriculum) leading to real learning (learned curriculum, latent curriculum).

The question of the nature and identity of content and processes

We intend to study the nature and identity of the knowledges that the teacher claims to teach as well as the corresponding teaching process that he reports.

Curricular didactical approach

With the concept of *curricular matrix* Lebeaume (2000) proposes to describe the nature and identity of technological education in France. This approach seems transposable to help inform the question of the nature and identity of knowledge (and actions) that the teacher claims to teach.

Dimensions of science education: knowledges, familiarity with scientific practices and epistemology

The school knowledges to be taught and the taught school knowledges are considered in their own and actual individuality. The question of genetic or teleological relationships they have with the academic knowledges (Chevallard, 1991) or *reference social practices* (Martinand, 1986) underpins the discussion about their identity and their nature.

Furthermore, science is a core contemporary human activity. As such, Science belongs itself to the curricula because it is a *reference social practice* that pupils have to know about.

Finally, we also have to integrate the epistemological dimension (philosophy, sociology and history) of the teaching and the part it plays within the teaching.

Science teaching processes

On one side we have the curricular prescription and on the other side we have the teachers' choices about appropriate teaching process for each of these dimensions; it is also linked to the question of the overlapping and interlacing of the teaching of these three dimensions.

Referring to Inquiry Based Science Education, studies about actual practices show pluralism and a dispersion (Calmettes, 2009), if not an inconsistency, hidden by an institutional consensus. Two extreme frameworks reflect as well the theoretical uncertainty. On one side, the inquiry pedagogical model - making reference to Dewey (Coquidé et al., 2009) – can be applied to science education. On the other side, school science inquiry can be presented as the natural transposition of scientific inquiry. In this case, we are given the justification *per se* of the relevance of such a transposition of the scientists' practices (Mathé et al., 2008). Again, we have to deal with the nature and identity of the processes used to teach knowledges to be taught within school science courses and their links with science as a social reference practice (Bisault, 2010).

We must remove semantic and didactical ambiguities. The didactical relevance of identified teaching processes needs to be assessed in the didactical field (didactical, didactics used in the French way, that is to say what refers to research about science education, in their specificity linked to the nature and identity of the knowledges to be taught as well as linked to the pupils' learning processes of these particular knowledges).

Didactical skills and epistemological skills of teachers

Teachers' didactical skills are revealed in the teaching of specific content. Related to Pedagogical Content Knowledge model (PCK) proposed by Shulmann (1986), they contribute to the guidance of the course in the designing phases. They refer to different theoretical didactical frameworks: level of formulation, problematization, conceptions …

Many studies also point to the reciprocal interactions between the epistemological conceptions of teachers and their conceptions about science education (Brickhouse, 1990; Waters-Adams, 2006). The prevalence of empirical-realistic (positivists) conceptions is particularly related to the own educational experience of teachers (Desautels et al., 1993).

Mixtures and solutions: special nature of knowledge to be taught

In the last elementary grades, the knowledges to be taught are not coming from a transposition of academic knowledges. They may even appear to be inconsistent with the concepts related to thermodynamics. The definitions (homogeneity, purity) stay at a phenomenological stage. The principle of conservation of mass during mixing is not specific to this theme. The quest for a distinction between "mixed and chemical combination" (Duhem, 1902) is of course not resolved here.

Here the knowledges to be taught refer mainly to everyday experience and social practices: the kitchen, the production of salt … they refer too to education for sustainable development: access to water, use of domestic water, wastewater treatment (mechanical stages of the treatment), water purification … the "technical abilities" that are practised here, seem to refer to everyday life as well as to the development of experimental skills (conservation mass, solubility limit).

Therefore it seems particularly interesting to see what "scientific dimension" the teachers attribute to the knowledge to be taught.

THE STUDY

Method

We have conducted case studies using the recording of the designing sessions.

We intend to be as close as possible to the practice of teachers. To do so, there are several conditions. The pace of work of the teacher is met (number of sessions, distribution of the sessions over time). For the in-service interviewed teachers, these work sessions are intended to be implemented with pupils in their actual class context.

In a process of explicitness (Vermersch, 2006), the researcher's role is to make clear the *how* of the process more than the *why*.

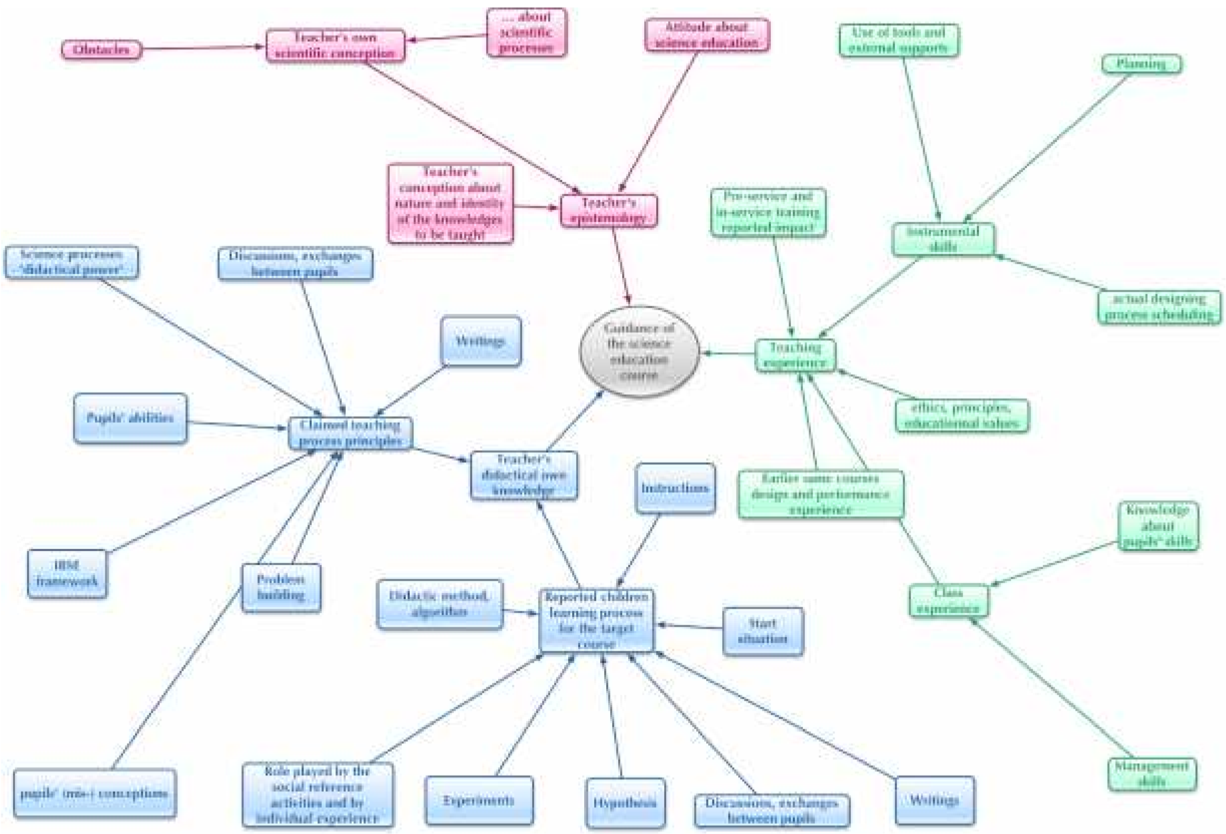
The sessions have been recorded on digital media and have been fully transcribed. The documents produced by the teacher during the sessions have been digitalized. For the analysis of the transcription, we have used a concept mapping software (Freemind). The significant elements (sentences, paragraphs) are characterized by nodes and are gradually reorganized over the analysis to achieve a mind map that fits our theoretical framework.

Target teachers

So far, we have analyzed three records:

Teacher	Seniority	Last elementary grades seniority	Remarks
alpha	22 years	All career long	Teacher-trainer
beta	20 years	9 years	Chose to work on states' changes, focusing on the mixing of states at the change of state.
gamma	Retired	All career long	Doesn't have to implement this work…

Figure 1: process matrix



Results

Global approach

We can not highlight a real difference between the way the teacher thinks the students are supposed to learn the knowledge taught and the teacher's conceptions about scientists' processes. There is no distinction made between the knowledges to be taught and the academic knowledges. The reference social practices and individual experiences are seen only as examples of applications of the concepts involved, not as an aim of teaching.

Process matrix

The designing of a course requires that the teacher solves a complex problem. The resolution of this problem demonstrates the manifestation of a contextual skill. It reflects the articulation of internal and external resources (Jonnaert, 2009).

As seen in some of our previous works (Kapala, 2010), we suggest to build what we call a *process matrix*. It refers to the categorization that comes from the analysis of designing sessions. It describes the designing of the targeted course as a combination of three dimensions (see Figure 1: process matrix).

Scientific epistemology and school knowledge epistemology of the teacher

- the conceptions of the teacher about the nature and identity of knowledge to be taught, particularly in relation to reference scientific knowledges;
- the conceptions of the teacher about science and science processes;
- the conceptions of the teacher about the "didactical power" of the "scientific processes" (connections between the conceptions of the teacher about scientific processes and the teaching processes he claims to promote);
- feelings about science education.

Teacher's PCK

- the principles stated by the teacher for teaching processes (based in particular on the knowledge of the teacher of the learning processes and the use he makes of it to design his own teaching);
- The description of the learning process as planned by the teacher for the targeted sequence.

Professional identity and experience of the teacher

- values and ethics;
- experience of the classroom (classroom management, knowledge of individual student skills, experience of similar sequences previously conducted);
- instrumental skills (programming and progressions, access to tools and external resources, actual organization of the designing work);
- part played (as reported) by the initial and continuing training.

Individual process matrix

The characterization of the discourse of the teacher during the designing phase according to this process matrix leads to define a profile. We proceed by identifying the categories that are present among those inventoried.

DISCUSSION

Some uncertainties…

This work seems to highlight some uncertainties in the discourse of the teacher characterizing the designing of the course.

Epistemological uncertainties

- academic knowledge vs. knowledge to be taught?
- Processes of scientific discovery vs. teaching/learning processes about knowledge to be taught?

Didactical uncertainties

- gap between the reported didactical intentions and the conceptions deduced from the proposed implementation;
- gap between didactical principles asserted and education actually planned;

Pedagogical uncertainties

- Opposition between autonomy and effectiveness;
- Opposition between the claiming of the value of some pedagogical principles and the expression of the identity of the teacher (super-regulator teacher, holder of authority in a transmissive way, time-keeper and syllabus-keeper).

The construction of categories and their measurement

At this point, we think about two main directions for further works. We must reasonably increase the corpus in order to stabilize the categorization proposed in the process matrix. The assessment of this categorization, eventually linked with a strong theoretical framework, will rely also on discourse analysis methods. Then we'll have to deal with the profiling of individual teachers by proposing a "measure" of categories and subcategories of the process matrix that would go beyond the binary occurrence test. For items found to be present in the individual and contextual process matrix, we would have to be able to evaluate the "weight" of each of them. This may go through a confrontation of the teacher with his or her own qualitative process matrix established by the researcher to conduct a self-assessment of the relevance and of the accuracy of the tool.

We do not address here the crucial issue of effective implementation of the course with the pupils. However fundamental and important, the comparison between the didactical analysis of the in-class interaction with the analysis we propose at the designing stage is a longer term objective.

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PROMOTING STUDENT-ACTIVE AND INQUIRY-BASED SCIENCE LEARNING BY THE PROJECT SALIS

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Abstract: This paper gives an overview about the project 'SALiS– Student Active Learning in Science', funded by the TEMPUS program of the EU for 2010-2012. SAliS is a reform initiative for middle and eastern European countries to innovate science teaching and teacher education. SALiS seeks to overcome a centralized and teacher-centered paradigm in science education as it is still predominant in different countries of central and Eastern Europe. Intended change concerns more student-active and problem-based science education under inclusion of students' hands-on and inquiry-based learning in the lab. Within an international network, ten partners from six countries work on establishing sustainable change i.e. in the training practices of prospective and in-service science teachers.

Keywords: science teacher training, curriculum innovation, inquiry-based science education, active learning, EU-projects

BACKGROUND

Science teaching pedagogies in many countries all over the world are still dominated by a teacher-centered approach. Although constructivism is widely accepted in science education research and theory, the practice in science classrooms in a lot of cases is still dominated by transmission oriented pedagogies of learning and instruction. This consideration is especially true for many countries in central and eastern Europe which are still on their way of reform from the communist time towards modern educational systems and practices (Kapanadze, Janashia & Eilks, 2010).

Anyhow, reform already started. But, reform in many countries in central and eastern Europe lacks by deficits in infrastructure and resources for scientific and educational exchange. That is why in cooperation of the Ilia State University in Tbilisi, Georgia, and the University of Bremen, Germany, the project initiative '*SALiS - Student Active Learning in Science*' was launched in 2009. Together with further partners from Ireland, Bulgaria, Germany, Georgia, Moldova, and Israel, an application for a reform network was submitted to the TEMPUS program of the European Union. The project was successfully approved in summer 2010 and will be conducted 2010-2012 with ten partners from six countries.

SALiS aims at innovating science teaching through a better inclusion of inquiry-based and student-active experimental learning in science classes. The project intends to promote i.e. open and inquiry-type lab-work as one of the foundations of modern curricular and methodological approaches in science teaching (Hofstein, 2004; Hofstein & Lunetta, 2003; Kipnis & Hofstein, 2007). These approaches aim to raise motivation, allow students gaining higher order cognitive skills, promote more effective learning of science concepts, and to contribute an advanced understanding of the nature of science (Kapanadze et al., 2010).

Recognizing that the teachers are the core for any innovation in educational settings (Eilks et al., 2006), the project aims at innovating science teaching in the above mentioned sense by improving teacher training. For the purpose described, all participating institutions are jointly developing modules and resources for science teacher training in inquiry-based science education. These modules aim on enabling pre- and in-service science teachers to strengthen hands- and minds-on student learning through innovative approaches to lab-work instruction, e.g. inquiry-type strategies, open lab tasks, or cooperative learning in the lab environment (e.g. Hofstein & Mamlok-Naaman, 2008; Kipnis & Hofstein, 2007; Witteck, Most, Kienast & Eilks, 2007).

RATIONALE

SALiS is jointly developing teacher training modules, school teaching materials, and a concept of implementation of SALiS via the use of low-cost lab equipment. A series of workshops is developed to train teachers and teacher trainers in central and Eastern Europe to apply and support constructivist teaching and learning scenarios, both in teacher training and school science education. Implementation of the training modules is supported by creating a collection of good practices from all partner countries and making them available to the other partners by translation and adoption. A web-based resource pool is made available in the different languages of the countries participating in the project offering teachers and teacher trainers material to innovate experiment-oriented and inquiry-based science education, e.g. in the field of low-cost-experimental techniques. A platform for exchange of inquiry-based and student-centered science lab activities for students in secondary schools and secondary science teacher training courses will be established.

Whereas respective facilities at least on a basic level are available in all SALiS partners from the EU countries, the project will strengthen the infrastructure in the six beneficiary institutions through equipping science laboratories for teacher training. SALiS is providing a concept of necessary infrastructure for respective teacher training labs. With funding from the EU necessary equipment for training teachers in SALiS-oriented and lab-based pedagogies feasible to the curricular targets of SALiS are installed. Detailed guides that describe the usage of laboratories in teacher training including questions of safety, logistics and maintenance issues are developed, and structures of curriculum materials describing lab activities for teacher training in the respective languages will be provided.

The idea behind establishing and equipping the SALiS-labs for science teacher training is to transfer already existing strategies from the EU partners in the use of lab equipment for promoting more effective strategies in science learning via students' inquiry-based lab-work in school science. I.e., strategies are implemented to base student active lab-work on low-cost lab techniques. Such techniques use everyday-life equipment on no or low costs for conducting experiments in science classrooms (Figure 1). The use of everyday-life equipment is combined with micro and half-micro approaches to reduce costs and demands for waste disposal, and the use of chemicals with low potential to be harmful or environmentally dangerous. Low-cost experiments are used as a strategy to allow for more student experimentation in science classrooms also under less well equipped conditions in schools in central and Eastern Europe. Thus, strategies are implemented allowing the teachers later on in their schools to do students' lab-work under low costs, with low risks, and aiming an environmentally friendly waste treatment (Poppe, Markic & Eilks, 2011).

Figure 1. Example or a low cost experiment developed by equipment form medical technology in the case of the Hofmann apparatus for the electrolysis of water. Low cost equipment (left) costs less 1 Euro, traditional glassware (right) is about 70-100 Eur.

IMPLEMENTATION

SAliS aims on creating the foundation for upgrading science education in many schools to a better level required for supporting the technological and innovative development of the society. Through the implementation of the training modules into pre- and in-service teacher training in all partner institutions the dissemination will become broad and sustainable.

SALIS aims on raising the qualification of staff for in- and pre-service teacher training courses concerning the SALiS philosophy by providing them specific trainings, but also by sharing experiences in good practice during placements in the partner institutions. Therefore, different training sessions have been organized by the partners from within the EU, in Limerick, Ireland, and Berlin, Germany. Staff members from the Central and Eastern European institutions were able to participate. The participants learned about good practices in pre- and in-service teacher training practices for future application of the skills and knowledge to the development of the curricular framework, course syllabi, lists of the experiments and lab equipment within their countries.

The SALiS Labs have been established in Moldova and Georgia. In Israel, partner institutions have enhanced their existing laboratories to suit the goals of SALiS better. The laboratories have included both more traditional equipment and that intended for training for the use for the low cost experiments in teaching.

Additionally, training courses for the teacher trainers and supporting laboratory staff from the beneficiary countries were launched. After an initial meeting with training sessions in spring 2011 in Bremen, respective one-week trainings were now made available in Georgia, Moldova and Israel during autumn 2011 driven by the whole SAliS consortium. Step by step the number of persons involved is raised by involving student teachers into the project to become part of the process of SALIS curriculum development and implementation through MA and PhD studies.

Via the curriculum development and exchange process, implementation of the SALiS training modules also takes place in pre- and in-service science teacher education within the participating institutions from the EU-countries. For this purpose, SALiS offers a collection of good practices, established science teacher training modules and builds up an international platform to transfer and further develop respective approaches, materials and techniques (Figure 1).

Figure 2. The SALiS web platform (www.salislab.org)

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TOWARD A THEORETICAL EXPLANATION OF THE INTERPLAY BETWEEN THE COLLECTIVE AND THE INDIVIDUAL DYNAMICS IN PHYSICS LEARNING

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Abstract: The paper concerns the analysis of a successful classroom experience where the students made evident progress in appropriating physics knowledge according to personal approaches. The data refer to the implementation of a teaching proposal on thermodynamics in a class of 20 students (17 year-olds) of a scientifically-oriented secondary school in Italy.
The main result of the analysis is the construction of a definition of appropriation, able to act as operative tool for recognising whether students appropriate physics in real classroom contexts.
The study is methodologically framed within the Design Studies. According to such a framework, the paper, although empirically-based, is theoretically-oriented: it is the first step of an iterative process aimed at developing a "humble theory" for explaining when, how and why appropriation is triggered and supported in real classrooms.

Keywords: Teaching/learning science, Design Studies, Thermodynamics, Secondary school level, Appropriation

RESEARCH FRAMEWORK

Background, purposes and research questions

Within European science education research, a great effort has been made in producing models ("sets of principles") for orienting the design and implementation of teaching proposals effective in promoting engagement and deep understanding in physics [e.g. the model of Educational Reconstruction (Kattmann et al., 1996); the model of Discipline-Culture (Tseitlin, Galili, 2005); the model of Longitudinal Development (Guidoni, 2004)].

Most of the models elaborated so far within science education operate at heuristic level: they act as "frameworks for action" (diSessa, Cobb, 2004). A framework for action is intrinsically and self-consciously heuristic. The purpose of a framework for action is to provide some useful foci and directions for the design of curricula or learning environments. However, because frameworks for action may involve multiple, diverse design elements and plans (some of which may have inexplicit underlying assumptions), frameworks for action are not themselves "theories of teaching and learning" that can be tested or falsified. The results of a research study are iterative in nature, and often involve making explicit and gaining a better understanding of the initial choices made by intuition or guess-work and guided by previous design experiences. In spite of the good practices documented in plenty of research papers, the heuristic level has two implications that represent barriers for making progress in developing our current understandings:

- *the proliferation of models*, because of the weakness of heuristics in testing the real held of a model and in comparing different models on the basis of their grip on reality.

- *the inability of the models of establishing "where we are"*, proved by the difficulty of exporting a model out of the research group where it is designed.

The Design Study (or Design Experiments) methodology provides important indications for promoting the development of theories within science education. The theory to which a Design Experiment aims is said "humble" since, unlike a grand theory or orienting framework ("set of principles which identify family resemblances and core values"), it has to be specific enough to be accountable to the activity of design. The theory must do "real work" for improving instructional design (Cobb et al. 2003; Tiberghien et al., 2009).

The paper concerns a theoretically oriented analysis of data collected during the implementation of a teaching proposal on thermodynamics in a class of 20 students (17 year-olds) of a scientifically-oriented secondary school in Italy.

During the implementation, the students made evident progress in finding out personal approaches for appropriating thermodynamics as they took part in the teaching/learning dynamics of the classroom.

The study is the first step in the process of developing a humble theory for explaining *how, when* and *why* individual process of appropriating physics knowledge are triggered and supported by collective dynamics managed by the teacher. In particular, according to the Design Studies, the data analysis we will present for showing *what works* will be underpinned by the concern for arguing "*how, when* and *why* it works, and by a detailed specification of *what*, exactly, *'it' [appropriation] is*" (Cobb et al, 2003).

To sum up, the study has been developed in order to answer the following research questions:

RQ1 - How can the word "appropriation" be defined so as to become an operative tool for recognising and evaluating the effectiveness of a teaching/learning experience (*What "appropriation" means*)?

RQ2 - What factors (features of the content knowledge reconstruction, collective activities, learning environment, mediation action,..) trigger and support individual processes of appropriation *(When, why and how appropriation occurs)*?

Choices at the basis of the educational reconstruction of thermodynamics

The teaching proposal on thermodynamics implemented in the class was designed so as to shape the learning environment as *a properly complex territory* (Levrini et al., 2010). At the basis of the notion of properly complex territory there is the idea that some forms of complexity in physics contents can be transformed into *productive complexities*, i.e. complexities that allow learning environments to be, besides intelligible, rich enough to enable each student to reach deep understanding and to exploit her/his cognitive potential.

The forms of productive complexity, implemented in the thermodynamics path, are:

(1) *Multi-perspectiveness:* the same contents have been analyzed from different approaches - the macroscopic and microscopic ones - treated consistently as two different models;

(2) *Multi-dimensionality:* a critical-philosophical reflection has been developed on the peculiarities of the two approaches through specific activities (questionnaire, discussions);

(3) *Longitudinality:* according to our idea that learning physics is a continuous process of widening, refining, revising knowledge already acquired, the thermodynamics ways of modeling systems, processes, interaction have been systematically compared with the models used in the theories previously studied (classical mechanics and special

relativity).

RESEARCH DESIGN AND METHODOLOGY

During the activities we collected data from different sources: written tasks (quantitative and qualitative problems on key concepts, including problems known as puzzling from the research in physics education); audio-recording of lessons; students' notebooks; notes of a Master student (GT, an Author) observing the classroom activities; questionnaires stimulating critical-epistemological reflection; video and audio recording of classroom discussions about the issues raised by the questionnaires; audio-recorded individual interviews to 10 students conducted at the end of the whole work; audio-recorded interview to the teacher and discussions with her. Since we could not complete 2 interviews because of time constraints, only 8 out of 10 have been taken into account for the analysis.

According to the Design Study methodology, we organized the research as follows.

RQ1 (*"What appropriation is"*)

Phase 1 – Working out the first operational definition of appropriation

In this first phase we focused the analysis on the data related to 5 students: their semi-structured individual interviews; their answers to questionnaires on a critical-epistemological reflection; their contributions to classroom discussions.

The 5 students were chosen on the basis of three criteria: our impression they could represent interesting cases for studying appropriation; the richness of their interviews; their being representative of the class (3 boys, 2 girls, with different levels of performance in physics and different roles within the classroom dynamics).

The data concerning each student were selected and re-arranged so as to draw "the student's profile". In order to make the 5 profiles comparable, all of them were constructed following the same steps: *i)* to pick up the *central idea*, if there is one, around which the student, during the interview, develops her/his discourse; *ii)* to see if and how such an idea is developed along the interview; *iii)* to reconsider the classroom discussions and the answers to the questionnaire in order to check if there is a relationship between the student's position during the interviews and what appeared in the previous activities.

The profiles' comparability allowed the operational definition of appropriation to be grounded on common features of students' discourses.

Phase 2 - Testing the definition

The definition of appropriation was tested against 3 other interviews in order both to refine it and to evaluate its operational power in "making invisible visible" (Strauss&Corbin, 1990). The 3 interviews seemed indeed, at the first overview of the data, cases of non-appropriation.

RQ2 (*"How, when and why appropriation occurs"*)

In order to start searching for an answer to RQ2, we abstracted, from the specific context, the first hypotheses about the structure of an humble theory, pointing out new foci of attention for designing a second level of the experiment within an iterative design.

DATA ANALYSIS AND RESEARCH FINDINGS

RQ1 – Phase 1: Data analysis and findings

The first main evidence which comes out from the comparison of students' profiles is the variety of the central ideas around which they developed their discourse (cfr. Table 1).

Table 1: *Central ideas around which students' discourse runs*

Michele	The Curiosity for "how things work"	"*I like Physics because it explains how reality works, so to say, I'm very curious about how objects work and natural events"*.
Matteo	The pleasure of speculating, in particular on the philosophical distinction between "being and becoming"	*"I believe that […] it is fundamental to build a basis and to speculate on how theories are found, how concepts are elaborated. These concepts will certainly last longer than formulas."*
Chiara B.	The pleasure of understanding by exploring and testing different points of view or perspectives	*"It may be more complete to try to analyze a phenomenon, or whatever is around us, from two different points of view rather than from one […]. It widened my view"*
Lorenzo	The need of searching for a unified consistent framework for deep understanding	*"One can see that everything is integrated, it is not divided in topics each with its own laws, instead everything can be connected, unified; the argument becomes wider, more uniform"*
Chiara C.	The fascinating search for "not obvious details that are usually taken for granted"	*[I like physics since] "obvious things are not taken for granted".[Of thermodynamics I like] "that it made me notice something I had not noticed before."*

The other very important evidence is the students' personal way of talking about temperature, since it was evident that they focused their attention on those features of temperature that were more meaningful to them.

Michele, for example, according to his general perspective, focused his attention on the temperature gradient because this is what makes engines work: "*Different temperatures are necessary…, only with different bodies with <u>different temperatures we can have a cycle and work</u>; different temperatures induce a heat exchange – we can call it so*."

Matteo, instead, focused his attention on the distinction between *ΔT* and *T*, because he saw, in this distinction, the philosophical difference between becoming (change) and being (a state): "*[I think that] Q=mcΔT is <u>becoming</u> […]… there is a change, that means everything is not stable and everything is not being […] the first relation [PV=nRT] is <u>being</u> because […] [there is] absolute temperature T, that doesn't change."*

Thanks to the construction and the comparison of the profiles, the following *features* of students' discourses can be recognised as signals they did appropriate:

a) the discourse is developed, around one key-idea, *consistently* along the whole interview;

b) the key-idea allows the formulation of arguments *on-task*, i.e. arguments which allow aspects of thermodynamics to be selected and meaningfully linked one to the other;

c) the keywords, around which each student constructs her/his arguments, reveal personal engagement, by being *genuine* and *emotion-laden*;

d) the argumentation is *thick*, i.e. it includes elements belonging to a meta-cognitive and/or epistemological dimension;

e) the specific approach to disciplinary knowledge is *not occasional* (it can be traced back to the student reactions in different classroom activities).

The acknowledgment of these features allowed us, finally, to formulate an operational definition of appropriation: *A personal process of content knowledge transformation that* *leads disciplinary knowledge itself* (feature b) *to be a consistent* (feature a) *and personal reconstruction of physics "signed" by the students*, where "signed" means that:

- the voice of the teacher is not present (feature c);
- physics content knowledge is assumed within a personal broad path to knowledge that goes far beyond the mere aim of learning thermodynamics (feature d, e).

RQ1 – Phase 2: Data analysis and findings

The 3 interviews against which we tested the operational definition of appropriation could appeared cases of non-appropriation because of:

- the lack of an evident personal idea around which student's discourse runs.
- the common "flat" sound of their ways of talking about physical concepts (*"In classroom, we have done…", "we have introduced the concept of temperature by…", "I remember that we had…", or "I don't remember if…");*
- the same strategy of talking about physics by going through, chronologically, the classroom activities.

Instead, the finer analysis we could carry out by applying the definition of appropriation shows that only one interview is an evident case of non-appropriation. Another interview reveals not only that the student appropriated thermodynamics, but also that appropriation was particularly difficult to be recognized because of a "natural", spontaneous cognitive resonance of the student with the inner physical language and its formal structure. The last interview shows that the student resonated with the global sense of the work, but she seemed to be still inside the process of searching for her own approach to learning.

To sum up, following the Design Studies methodology, this first part of the study allowed us to construct a definition of appropriation which is *operational* in two senses: *i)* it includes the indication of what *observable features* must be searched in students' discourses for recognizing appropriation; *ii)* it is *effective* for recognizing appropriation also in cases where it is not evident.

RQ2: Data analysis and findings

In order to start the iterative process aimed at answering RQ2, a theoretical move is needed. In analogy with what happens in the physics of complex systems, the kind of humble theory we have in mind is shaped as a dynamical model comprised of:

a) boundary conditions, i.e. those context conditions which make the learning environment suitable and fruitful for triggering and supporting appropriation;

b) a dynamical mechanism lying at the back of the process, i.e. a mechanism enacted and managed by the teacher in order to make *individual cognition, collective dynamics* and the *disciplinary knowledge* resonant with one another.

Good candidates to be boundary conditions

In this specific experiment we see three features of the learning environment that appear good candidates to act as fundamental boundary conditions. They are: *i)* an appropriate content reconstruction where forms of productive complexity are implemented; *ii)* individual attitudes, habits and skills; *iii)* established classroom norms. More specifically:

i) Multi-dimensionality and multi-perspectiveness of content reconstruction acted, reasonably, in a fruitful way for encouraging appropriation since they opened both a plurality of contexts where the same concepts could be applied, and a plurality of points of view through which the students could take inspiration for finding out one's own. In other words, multi-dimensionality and multi-perspectiveness probably are responsible for opening, in the experiment, a suitable *space of possibilities* for making thermodynamics resonate with a plurality of cognitive styles and intellectual interests.

ii) The individual attitudes, habits and skills, that we recognised as particularly evident in those students who appropriated thermodynamics, are:

- the ability of recognizing, in the conceptual scenario, a space for multiple possible paths for understanding;
- the ability of moving back-and-forth from local details to global views;
- the emotional disposition to taking care and accountability of their learning and to venturing their guess for anticipating where the various paths for understanding can lead.

In the discussions with the teacher, she stressed both her attention in fostering such attitudes and skills, and the inner difficulty met by secondary school students:

> *"Very often I say to them: 'Try, try to imagine, to anticipate your mind what will happen if you take one way or ano r one… or a strategy of thought.' […] Young students are more and more fixed i a present dimension 'here and now'. […] I always make it very explicit that playing in the future is a VERY DIFFICULT task, because the rules of the scientific game are well defined and severe and, at the end, not all the ways work (unlike in analyzing a poem, where every route that makes sense to you HAS, somehow, a sense). They have to try for themselves, not for me. This game is very fruitful for managing the anxiety due to learning science and for testing one's own emotional world. They feel much more quiet and relaxed if you tell them that."*

iii) The established classroom norms that reasonably acted in a fruitful way for triggering and supporting appropriation are the following:

- *students' trust* in teacher's attitude of letting them freely play with their ideas (suspending judgement);
- distributed awareness that *each student could and had to provide a contribution* to the collective dynamics.

> *"When students are trying to play with their ideas, it is obvious that I have to suspend the judgment. I tell them that it is a difficult game but that it is worthwhile for them, for their growth. So I have to respect it… I have to be coherent with the message I want to pass… […] My idea is that THEY have to assume the accountability of that. They do not have always to search my approval. If they feel comfortable with their stories, the stories are ok. I only have to help them to respect the constraints posed by physics. This is not easy, but I do believe this is our role as teachers."*

Dynamical mechanism of mediation

Once boundary conditions are satisfied, our hypothesis is that a specific dynamical mechanism of mediation is needed for triggering and supporting appropriation; a mechanism enacted and managed by the teacher in order to make *individual cognition, collective dynamics* and the *disciplinary knowledge* resonant with one another. The discovery of such a mechanism is maybe the more challenging and demanding aim of our proposal of developing a humble theory. We are indeed looking for a description of the mechanism that is specific enough for explaining *how* and *why* teaching fosters and supports personal appropriation, but also not so specific to force different teachers to change their teaching styles.

The next step of the research will be the analysis of data we have already collected in three further experiences realised by two “new” teachers (one of them indeed implemented the same proposal, during the same period, in two different classes). The three experiences share with the experiment analysed here the kind of upper secondary school (“Liceo Scientifico”), age and socio-cultural context of the students, the strong involvement of the teachers in their work. What makes however these data particularly interesting is that one experience, out of three, was unsuccessful: not only appropriation did not occur (with only few exceptions), but also the forms of complexities seemed to play a counter-productive role in fostering basic understanding. A further element of interest is that the unsuccessful experience is one of the two experience realised by the same teacher.

This specific situation will allow us to treat the analysis of the boundary conditions somehow independently of the dynamical mechanism of mediation: being, indeed, the teaching proposal and the teacher the same in a successful and in the unsuccessful experience, we expect to find different boundary conditions responsible for the different reaction of the two classes.

FINAL REMARKS AND IMPLICATIONS FOR RESEARCH

Appropriation is chosen, in this research, as the core idea for recognising whether a teaching/learning experience in a real classroom is successful. Appropriation includes more than deep understanding: it implies that each student situates her/his understanding within a wide personal project of intellectual and emotional growth, according to her/his cognitive style and cultural interests. In the study, an operational definition of appropriation has been built and tested against complex data. We have moreover tried to extract, from our experiment, the draft structure of a humble theory aimed at explaining when, how and why appropriation is triggered and supported in a real classroom. According to the Design Studies methodology, the last results represent the new foci of attention for designing and analysing further experiments within an iterative design.

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TEACHING AND LEARNING SEQUENCES FOR THE STUDY OF ELECTRIC ENERGY AT PRIMARY SCHOOL

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Abstract: In this paper we report the design of an implementation of a teaching sequence of energy and electricity. This sequence was designed following the principles proposed by Sanmartí (2002). A voluntary female teacher helped to our sequence in her 6th grade primary classroom. Her students were aged 10-11. We collected students' productions to be analyzed. From the data obtained, we concluded that our methodology has stengths and weaknesses. We recognized that our teaching sequence has the adequate motivational dimensions and the social significance (contextualization). The whole group showed a 100% good classification of materials and the students succeed building by their own a list of safety rules for an electrician. The weak point was the final evaluation, only 20% built a correct map. The results were not conclusive because we assume that students managed this tool.

Keywords: electric energy, energy, teaching and learning sequences, primary school.

BACKGROUND

The energy concept is one of the most important ideas of science, independently of the discipline which study it: Physics, Chemistry, Biology, etc. At the same time, it is one of the most abstract concepts known and its complex character has intrigued a good number of researchers for more than a few years and has generated many different research areas (Saglam-Arslan, 2010).

At present the education of the concept of energy has started at primary school (Spain, Mexico, Chile, United Kingdom, Malta, etc.). In spite of some researchers that do not agree with its introduction at this stage of formation, Warren (1982) stayed that this concept does not being taught until the students have acquired a high level of abstraction in their reasoning. While Solomon (1983) and Trumper (1993) agree that the teaching of this concept must begin as soon as possible. As can be seen, in the international literature we find positions against or in favour of the introduction of this concept in primary school.

Nowadays, in many developed or not developed countries this concept is taught to early age. Its study is associated with environmental problems which concern to all of us (Rizaki & Kokkotas, 2009) and our country is not the exception.

Designing teaching sequences is a complex activity due to the relationship between knowledge, learning and teaching without forgetting the institution in which the teaching and learning activities takes place (Buty *et al*. 2004).

FRAMEWORK

According to Méheut & Psillos (2000) a Teaching-Learning Sequence (TLS) is used to denote the close linkage between proposed teaching and expected student learning as a distinguishing feature of a research-inspired topic-oriented sequence. A TLS is both an interventional research activity and a product, like a traditional curriculum unit package, which includes well-researched teaching-learning activities empirically adapted to student reasoning. On the other side, recent studies indicate that the most successful TLS are those in which the teacher engages the students' thinking on the topic and produces a sequence that achieves a higher interest and satisfaction in their students.

A variety of TLS's topics have been studied, such as: students' conceptions, features of the scientific domain, epistemological assumptions, learning perspectives, current pedagogical approaches and features of the educational context (Méheut, 2005). Despite this variety, Lijnse & Klaassen (2010) have stated that in the international research literature little information has been published about TLS.

These were some of the reasons which motivate us to share this study concerning the teaching of electric energy at primary school, because almost all the times communication is also made more difficult by the fact that the teaching materials developed are mostly only available in local languages. If they are published at all, details about them can often only be obtained from publications in local journals aimed at teachers.

For the design of this sequence we follow Sanmartí TLS proposal (2002) which includes these four steps: exploration, introduction of new points of view, synthesis and application, and generalization. In this model the TLS planning is organized according to the teaching purpose going from the simple to complex ideas and from concrete to abstract ones.

This TLS at a medium-level (according Kariotoglou and Tselfes 2000) has being designed for the following teaching purposes:

1. To explore the students' beginning ideas of the energy and electric power concepts, bearing their experiences and daily contexts;
2. To present the electrical closed circuit as a necessary system to the electric energy study by introducing the electrical characteristics of different materials (conductors and insulators);
3. To introduce the idea of energy transfer and transformation for the study of the production of electric power, fundamentally the produced on a large scale in the electric power stations, and its employment to obtain other types of energy;
4. To support the students in order that they identify the technological applications of the electricity, emphasizing the ideas of social relevancy as: rational and efficient use of the electric power, rational use of natural renewable resources, environmental problems, communications and safety measures.

PURPOSE

The aims of the present study were:

1. Does Sanmartí TLS model work to teach electric energy at 6^{th} primary level?
2. What are the advantages and disadvantages that the teacher observes during the TLS?
3. How students progress in the understanding of electrical energy?

The study was part of a larger programme aiming at the introduction of innovative ways of teaching and learning science in primary school.

RATIONALE

According to the new curriculum for basic education in Mexico (SEP, 2009), one of the competencies that is claimed students acquire along their primary instruction is the "competition for living together" which implies a good relationship with others and with Nature, that is why it is considered important that a student, at the measure of his/her intellectual capacities, should learn why energetic resources are limited and how and why he/she must take care of them to guarantee a sustainable future. To contribute to this idea we propose the design of a TLS for the study of electric energy at primary school using a macroscopic model with a constructivist approach.

METHODS

30 Mexican students about 10-11 years old participated in the implementation of the TLS. The sequence took place for an hour and a half per day. Over a 2-week period, in the usual form groups and in the normal timetable. The TLS has the following stages:

a) *Exploration*, which includes: choosing words and making sentences using the energy concept, exploring the beginning ideas about energy and electric energy and making a list of appliances of daily use;

b) *Introduction of new ideas*, such as: introduction of the energy concept, types of energy, as well as its transference and transformation; observing some phenomena and applying the energy concept and its transformation; making an electrical closed circuit (a bug model) and classifying materials as conductors and insulators;

c) *Synthesis of new ideas*, for example: energy transformations, calculation of light consumption at home and safety rules for electricity manage, and

d) *Application and generalization*: describing the functioning of an electric power station and building a conceptual map.

Frequent meetings with the teacher taking part in the experiment allowed us to work out a precise protocol and to take into account the students' cognitive skills and the normal operating routines of the school. We defined an accurate protocol with the teacher in order to collect the data during the classes. Each stage of this protocol was supported by a working sheet (five sheets for each student for the whole study). The data were the students' written productions in every tested form and audio and videotape recordings of the teacher's interventions. After the sequence, we assessed a written conceptual map per student to confirm various aspects of the individual model built during the learning sequence.

RESULTS

In general, if we look at the utilization of a sequence as a teaching and/or research tool, several kinds of validation appear. Some methodological approaches aim at evaluating the effectiveness of a sequence by comparing the students' cognitive final stage with their initial one. Other approaches illuminate students' cognitive pathways all through the teaching-learning process. For our work we will only focus if the collected data will assess the global effectiveness of the TLS rather than permit a precise analysis of it.

Analyzing the working sheets produced by students during the sequence and their answers we tried to demonstrate the pedagogical effectiveness of this TLS with regard to the aims of this study.

1. On the whole we conclude that Sanmartí TLS model works good to teach electric energy at 6th primary level. This study is an evidence-based teaching practice which

has proved effective in improving the motivation, engagement and academic and social outcomes.

2. Respect to the advantages of TLS implementation, the teacher feels more confident teaching this concept nowadays. She says that it was an innovative and different way to teach electric energy and she found that the experimental activities are not difficult to do. On the other hand, she said that teaching electrical energy by this TLS is time consuming, reason for avoiding some activities of the TLS.
3. About the students' progress in the undestanding of electrical energy we noticed these indicators:
   a) The whole group (100%) classified materials as conductors and insulators correctly (Fig. 2), previously they built their own electrical closed circuit (Fig. 1);
   b) All the students succeed building by their own a list of safety rules for an electrician using the concepts of conductors and insulators.

Other students' findings when applying this TLS were:

1. About the beginning ideas of the energy concept, a vast majority of the students (80%) associated the word energy with: force, appliances, movement and batteries.
2. With regard to the appliances which consume more energy, they mentioned computer, refrigerator, television and mobile phone.
3. In relation to the introduction of energy transfer and transformation, the types of energy most mentioned (80%) by students were electric (electricity) and calorific energy (heat).

Although this sequence of activities our attention was placed on students, it is noteworthy that the teacher made some changes (we hoped) to the sequence. She changed the time of each activity according to her agenda. She covered all the phases of the model, however, she avoided some specific activities like: calculation of light consumption at home and the functioning of an electric power station. She justified this on the grounds that such activities were complex or time consuming.

Fig. 1. Students building the bug model circuit.

Fig 2. Students classifying materials as conductors and insulators.

CONCLUSIONS AND IMPLICATIONS

The analysis demonstrates stengths and weaknesses of our design methodology. We recognized that our TLS has the adequate motivational dimensions and the social significance (contextualization). The weak point was the final evaluation because we assume that students managed conceptual maps. The results were not satisfactory, only 20% built a correct map.

In science, as in every subject, choices about what to teach, what approach to take to a topic, which aspects to emphasise, the depth of treatment, and so on, are value-laden. They are influenced by our views on why we are teaching science to any particular group of learners, what teaching and learning science means, and why certain outcomes are worthwhile.

The actions and decisions in the classroom belong to the professor, so when someone accepts the adoption of guiadance on how to teach X, we should anticipate and accept, that any particular example of research-informed guidance on 'how to teach X' will not be adopted by some teachers, even if there seems to be quite clear evidence in favour of doing so, because they do not share the values implicit in that guidance (Millar, 2010: p.58).

Demostrating the feasibility or effectiveness of a sequence can be linked to the pragmatic perspective of developing "good educational products".

PERSPECTIVES

To improve this work we will do the next actions:

- To apply in depth the "*developmental research*" as defined by Lijnse (1995): data analysis makes it possible to discuss and improve the effectiveness of teaching-learning strategies.
- To invite more teachers to participate in order to increase the sample (students as well);
- To improve the weaknesses identified by us and by the teacher (which will probably be different);
- To practice conceptual maps with children before TLS introduction (if we decide to use this tool again);

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LESSON PLANS FOR STUDENT LANGUAGE HETEROGENEITY FOR THE TOPIC "MATTER AND ITS PROPERTIES"

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Abstract: This paper discusses a collaborative research and development project carried out by science teachers, German as a Second Language teachers, and science educators. The project follows the model of Participatory Action Research in science education. It focuses on the development of teaching modules for early lower secondary science (grade 5, age 10-11) on different topics, including matter and its properties. The teaching modules consequently implement learning content and language as envisioned in the Content and Language Integrated Learning (CLIL) approach. All of the lessons are structured using cooperative and autonomous learning methods. The accompanying research attempts to answer the question of what extent it is possible for pupils to learn science content, scientific terminology and the German language simultaneously as the learners work autonomously in cooperative settings. Data was collected from student feedback questionnaires, cognitive tests, and teachers' feedback and classroom observation. The results show that the lesson plan in question can potentially improve students` learning of science subject matter while bettering the participants' German language skills at the same time. This paper provides insights into the structural elements of the lesson plan and also reflects upon the potential and impact of the cooperative and autonomous learning method selected for the success of the lesson plan.

Keywords: Linguistic Heterogeneity, Science Lesson, Content and Language Integrated Learning, Cooperative Learning, Participatory Action Research

THEORETICAL BACKGROUND

Adult multilingualism is viewed as advantageous in the current, global business world and community. However, multilingualism in the school context is perceived as a source of conflicting issues and deficits (Gogolin, 2005). Ever since the first PISA (OECD, 2006) and IGLU studies (Bos et al., 2003) were published, student linguistic issues have been getting increased attention in political discussions (Hesse, 2008). From the starting point of large, international studies such as PISA, UGLU, etc. we recognize in general that multilingualism (in most cases bilingualism) is primarily a disadvantage, especially among younger learners. In the German context this disadvantage becomes larger for families with migration backgrounds in their history. The majority of German pupils with migration backgrounds only begin to learn German in a standardized, structured fashion after entering primary school at the age of 6-7 years (Brandenburger, 2007). Outside of school, they almost exclusively speak their mother tongue with their families and friends. This translates quite often into students with migration backgrounds achieving overall lower educational levels than native German speakers due to lacking language skills. Reich and Roth (2002) discovered that only in a few cases do bi- or multilingual pupils ever reach the language standard of native speakers. Furthermore, the official school language during lessons, German, is a huge challenge for most such students for two reasons: 1) they often don't know the grammatical rules of either their own spoken language or German (Maas, 2005) and 2) explicit instruction in their mother tongue is not offered in school settings (except perhaps in rare instances where larger minority languages like Turkish or Russian are offered as part of the school curriculum in larger schools. Seehouse (2004) has shown that students have relatively few possibilities to participate actively and productively in regular classroom settings. They experience the new language receptively and have less opportunity to actively use it in order to develop their linguistic competency. Furthermore the undeveloped speech faculties of non-native speakers make content learning difficult. Thus, regular Chemistry lessons turn into a bilingual minefield for such learners. They not only have to assimilate the basic content presented in the lesson, they must also understand and learn the specific language belonging to Chemistry and the scientific endeavor (Leisen, 2004). These students lack the language competencies necessary to communicate and to actively participate the lesson (Söhn & Özcan, 2005; Deppner, 1989) due to this combination. On the other hand, however, Riebing and Bolte (2008) have found that multilingual students have high meta-linguistic competencies in comparison with monolingual, native speakers. This is because they have already been actively exposed to learning more than one language system. Pupils with migration backgrounds proved to be more attentive with respect to the language used in Chemistry lessons. However, answers given by these students also tend to be much shorter and less complex, with less usage of specific, scientific terminology. Additionally, German teachers often do not accept the teaching of German as a foreign language as a necessary goal within their own science lessons. In many cases, they attempt to relegate it to an ancillary position as an issue which should be addressed by other subjects, e.g. in German lessons (Tajmel, 2010).

The achievement of *Scientific Literacy* in all citizens has been the main goal for teaching science at the secondary level since the 1990s. Standards and benchmarks for *Scientific Literacy* have been published worldwide (e.g. KMK, 2005). Furthermore, *Scientific Literacy* states that pupils in school should be able to communicate correctly with different addressees. This includes taking part in public and open discussions about scientific, technological, social, and ecological topics. In order to achieve this aim, it is important that students' linguistic competencies also be emphasized in science lessons. Looking to the situation described above, there is a need to work on this issue.

RATIONALE

This research and development project aims to develop teaching methods and learning materials for linguistically heterogeneous classes, including research on their effect on teaching and learning. A group of science teachers, German as a Second Language (GSL) teachers, and science educators combined to joint develop modules for science lessons. These teaching units focus on beginning secondary school lessons on various topics, e.g. matter and its properties. Consequently, the lesson approach selected and the learning materials developed combine both content and language using Content and Language Integrated Learning (CLIL) along with cooperative and autonomous learning.

Starting from this point the main research question is:

> *To what extent it is possible to simultaneously learn scientific methods, terminology, content matter and the German language as students work in a cooperative, autonomous learning environment?*

METHOD

This project is based on the Participatory Action Research (PAR) design of science education (Fig. 1; Eilks & Ralle, 2002,). PAR is a joint effort between teachers and science educators for curriculum development, educational research, and classroom innovation.

This paper describes the results of a group of five Chemistry/science teachers and three GSL teachers from different schools in the State of Bremen (Germany), who are collaborating with a university researcher from chemistry education. The group meets regularly every three to four weeks and has been developing lesson plans concerning CLIL for about a year now. At the group meetings, changes in teaching practices are proposed, negotiated, and refined so that the resulting structures can be tested and applied in classroom situations before being reflected upon and improved.

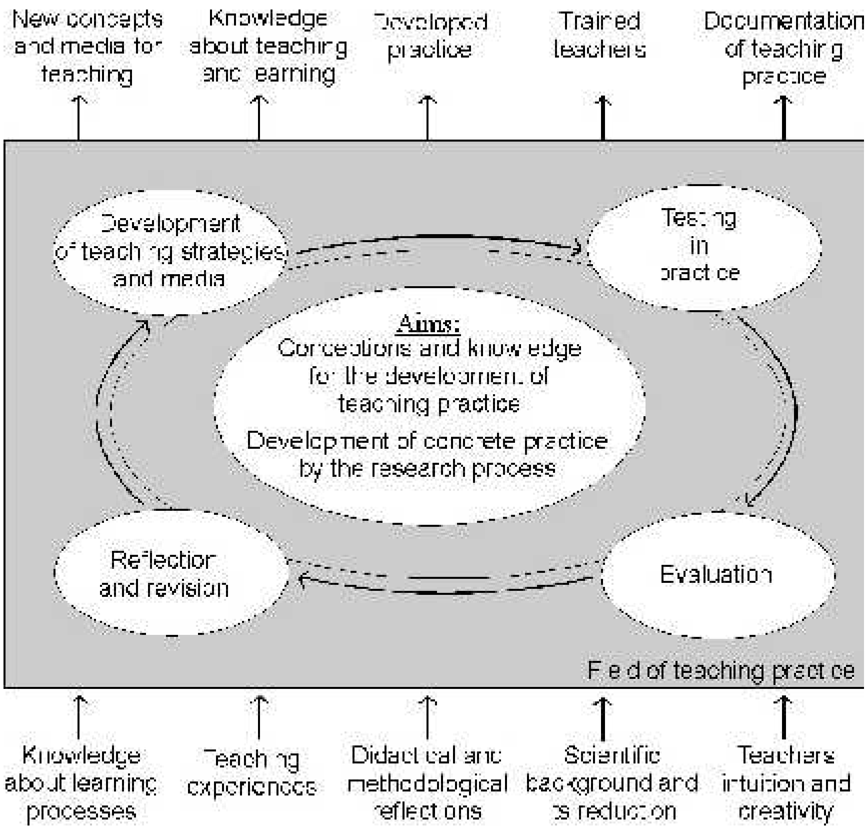

Figure 1: PAR within science education

Four different lesson plans have been developed using this model. The development and evaluation of a lesson plan for “Matter and Its Properties” will be presented in this paper. Table 1 shows an overview of the development and evaluation process. Three of the six groups were continuously accompanied and observed by university researchers. After each lesson was over, the teachers performed self-reflection exercises and documented their progress using narrative reports. These experiences were regularly discussed by the entire PAR group. All of the learning groups took part in a cognitive test and were required to provide student feedback via an evaluation tool comprised of a combination of both an open and a Likert questionnaire.

The lesson plan for “Matter and Its Properties” occurs in two phases: 1) experimenting and 2) exchanging. In the first phase students are divided into two groups: chemists and physicists. Both groups work at stations conducting experiments on the properties of matter. The chemists focus on chemical properties and the physicists concentrate on physical properties. Both groups are structured around a research folder containing helpful materials. The folder is very similar in both cases. The first page lists all the materials needed to carry out the experiments. As a language aid, German vocabulary and definitions are provided, including the definite and indefinite articles for German masculine, feminine and neuter nouns in both the singular and plural forms. This is important, since many German words undergo pronunciation changes and/or receive new word endings in the plural form. Every worksheet begins with a sentence describing the aim of that particular station. Linguistic aids are offered for topics which the teachers in the group viewed as necessary.

In the second phase, the original groups from the first phase are mixed to form new groups. In this next phase, two chemists and two physicists work together. Their job is to exchange the knowledge which they had discovered in their original role with their new partners. They also work cooperatively in an exercise book covering both topics.

Furthermore, the entire lesson plan is supported by laminated “Help Cards” and “Solution Cards” which are available on the teacher's desk in case pupils reach an impasse.

May 2010	analysis of relevant literature; collecting ideas for methods and experiments; first provisional structuring
End of June 2010 (Meeting of the group)	presentation of the provisional lesson plan; negotiating and restructuring the first part of the lesson plan; collecting ideas for structuring the second half
July to August 2010	revising the lesson plan
September to October 2010	testing of the lesson plan in two learning groups; observation of the lessons by one university researcher and teacher self-reflection after each lesson
Mid of November 2010 (Meeting of the group)	reflection on first experiences with the whole group of teachers; negotiating the test and students questionnaires
November to December 2010	testing occurs in another learning group; test and student questionnaires
Mid of December 2010 (Meeting of the group)	reflection in the whole group
January to June 2010	testing in another three learning groups occurs; test and student questionnaires

Table 1: Development and evaluation

SAMPLE

Up until now, the testing and evaluation phases have been carried out using six learning groups (age range 10-11) with a total of 119 students. The lesson plan was tested in different schools in the city-state of Bremen, Germany. All of the schools which participated the study are located in the suburbs of Bremen. They are in parts of the city which have lower social and educational backgrounds, including a high number of residents with migration backgrounds. Table 2 presents some of the characteristics taken from the sample.

Characteristic		Number	Percentage
Sex	***Female***	72	60,5
	Male	47	39,5
Students with a migration background		67	56,8
German not spoken as the home language		45	37,8

Table 2: Sample characteristics

RESULTS

Cognitive outcome: The cognitive test was pre-structured by the teachers according to their personal teaching experiences. The majority of students passed the test successfully, achieving scores of higher than 50% of the total available points. A high percentage of all student groups had scores of "good" or "very good", based on the pre-structured pattern for evaluating the test. A total of 84% of the participants achieved more than 80% of the total points possible. Such achievement was considered to be high and a quite remarkable factor by the teachers.

Teaching methods: Initially, the teachers were reluctant to use autonomous teaching strategies for students with language shortfalls. They expressed considerable fears of leaving such young students alone in a cooperative learning setting. This was not just because of the work on specific scientific topics, but also because the learners would have to simultaneously deal with any difficulties arising from their German language skills. Nevertheless, the teachers were open to experimentation when it came to applying the scheme. After carrying out and reflecting upon the lessons, the teachers’ attitudes changed quite considerably. They were happy with the product they had produced, with the openness of the lessons, and with the overall motivation of their students. This reaction consistently fits the feedback given by the students. The learners judged the lessons to be remarkably good, especially concerning aspects such as help in the verbalization of their own ideas and knowledge, the autonomy of learning, structured cooperation and communication. In particular, they mentioned that the working materials had helped them to better understand the topic both by themselves and within their peer-group. They also agreed that their ability to express their own ideas and results in proper German had grown commensurately.

Process of development: It was easy to observe how the teachers directly influenced the learning process. They considered possible difficulties which they would encounter in the overall approach and suggested appropriate corrective changes. Furthermore, the differing competencies and experiences combined by teachers of science and GSL during the process complemented one another. The teachers did not solely focus only on developing materials which increased the students` scientific knowledge. Instead, they allowed the researchers to sufficiently address and undergird additional factors. These included the simultaneous enhancement of the learners' German and scientific language skills while the pupils were actively engaged in assimilating specific, scientific content knowledge. More details will be given in the full paper.

CONCLUSIONS AND IMPLICATIONS

Even though the process of collaborative development was new for both science teachers and GSL teachers, each group dealt with it in an autonomous fashion, aided by the newly-created teaching materials for the lesson plans. This also held true for the aspects focusing on the teaching of the German language and teaching methods employed. The students were able to cooperatively manage the lesson plan, despite initial doubts expressed by some of the teachers. The expectations of the teachers, which had been set down in the form of a pre-structured test, were exceeded by the pupils, most of whom achieved unexpectedly positive cognitive results. Although this test is limited in scope for judging long-term learning effects, the short-term results provided us with a good baseline for measuring whether students can understand topics on their own, including expressing themselves more easily and correctly through the German language. The initial data seems very promising for implementation of further lesson plans and units which combine the learning of scientific knowledge, German language skills and cooperative learning methods.

Cooperative efforts between teachers of science and those for German as a Second Language seemingly offer attractive possibilities for developing new teaching materials which further linguistic heterogeneity in Chemistry/science lessons. Researchers also had a chance to exchange their personal experiences with linguistic difficulties, knowledge of their students, and any pertinent interdisciplinary information, including methodologies. Furthermore, cooperation between experts stemming from multiple disciplines offers a promising path for creating motivating and highly attractive learning environments. This can bolster science teachers as they attempt to aid their students in simultaneously mastering both scientific content knowledge and German language skills.

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THE DEVELOPMENT AND VALIDATION OF A TOOL FOR MEASURING TOPIC SPECIFIC PCK IN CHEMICAL EQUILIBRIUM

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Abstract: The study outlines the development and the validation of an instrument to assess the quality of topic specific PCK, related to the teaching of chemical equilibrium. The instrument uses five topic specific components, namely, learners' prior knowledge, what makes a topic difficult to teach, curricular saliency, representations and teaching strategies. The instrument was administered to groups of pre-service and experienced teachers. The reliability of the tool is reflected to be high as shown by the values for both *person* and *item* indices calculated using the Rasch Statistical Model. For the inexperienced pre-service teachers, the classical measure of reliability (Cronbach Alpha coefficient) was calculated as 0.82, while the person reliability was 0.90 and the item reliability 0.95. For the experienced teachers, the person reliability was also found to be high at 0.91 and item reliability at 0.88; and an acceptable degree of internal consistency (Cronbach Alpha = 0.91). In both cases the item and measured person scores reflected error estimates well inside the conventionally acceptable range of -2 and +2. A further indicator of validity of the tool was the empirically calculated hierarchy of test items found similar to the theoretically predicted pattern for both teacher groups.

Keywords: Pedagogical Content Knowledge, Topic Specific PCK Tool and Subject Matter Knowledge.

INTRODUCTION

Although many studies have elucidated the Pedagogical Content Knowledge (PCK) of both experienced and inexperienced teachers, there is still considerable debate regarding its exact nature. PCK remains an elusive and a tacit construct. There seems, however, to be general agreement that it is a useful and powerful construct, especially for teacher education (Kind. 2009). Much research has been devoted to characterising PCK in practice (see Kind, 2009) and capturing and portraying it (e.g. Loughran, Berry, & Mulhall, 2006), but fewer attempts have been made to assess its quality in science education. Part of the problem in this regard is the lack of agreement that still exists about what exactly is being assessed. In our view, the value of PCK for improving the quality of teaching lies in its topic specific nature, pointing to the need for a topic specific instrument. Thus the discussion herein is part of a larger project, with the specific purpose to design an instrument for measuring the quality of PCK in various selected topics, starting with the concept of chemical equilibrium as illustrated in this paper.

Some research does exist on the development of tools for assessing the quality of PCK, both generic (e.g. Loughran, Berry, & Mulhall, 2006) and topic specific (e.g. Riese & Reinhold, 2009). Work in this area began in the field of mathematics education, but is gaining momentum in science education, exemplified by a paper presented at the 2009 European Science Education Research Association (ESERA) conference (Rohaan, Taconis, & Jochems, 2009) and recently that of Park et al., (2010). As with much of the work quoted above, our interest lies in the development of an instrument that will be easy to administer to large numbers of teachers, with a view to establishing qualitative and quantitative baseline information about their topic specific PCK.

CONCEPTUALIZATION OF THE TOPIC SPECIFIC PCK TOOL

Different models of PCK are employed in the studies cited above but our interest is predominantly in topic specific PCK. To this end we have developed the construct of Topic Specific PCK (Mavhunga & Rollnick, 2011) which as a concept is related to Ball et al's *specialized content knowledge* for teaching (Ball, Thames, & Phelps, 2008). We regard Topic Specific PCK as the understanding that provides the needed knowledge for Subject Matter Knowledge (SMK) transformation in a particular topic. The conceptualization of Topic Specific PCK is premised on the understanding that transformation of SMK is one of the key elements in the establishment of PCK. For teachers with high quality PCK, each topic is transformed as teachers reason about its teaching (Shulman, 1987). When a specific topic is thought through, certain topic specific components of PCK are considered. We identify these as (i) Learners' Prior Knowledge, (ii) Curriculum Saliency (deciding what is important for teaching and sequencing), (iii) What makes the topic easy or difficult to understand, (iv) Representations including powerful examples and analogies and (v) Conceptual Teaching Strategies. All these components are similar to those established in Geddis and Wood (1997). For each individual topic engaged through these topic specific components, the resulting knowledge will be different and specific to that topic.

The Topic Specific PCK tool is thus structured according to the above listed five components of Topic Specific PCK. Each of the components is briefly described below to provide meaning.

(i) Learner Prior Knowledge

Learner Prior Knowledge refers to common students' misconceptions and alternative conceptions about a particular content.

(ii) Curriculum Saliency

Curriculum Saliency refers to the learning of the various topics relative to the curriculum as a whole. It is the understanding of which topics are the most central and which more peripheral. Such understanding enables teachers to judge the depth to which a topic should be covered and hence the amount of time to spend on it.

(iii) What is difficult and what is easy?

The ability to identify gate-keeping concepts, within a concept, that are difficult to understand, triggers dedicated awareness and possible interventions for teaching them.

(iv) Representations

This component refers to a range of subject matter representations including examples, illustrations, analogies, simulations and models. Chemistry teachers, in particular, make extensive use of a variety of representations of their subject matter.

(v) Conceptual Teaching Strategies

Conceptual Teaching Strategies refers to effective instruction strategies for particular misconceptions, known areas of difficulty to learn, or known importance of concepts. It refers to the use of combinations of conceptual principles and rules of a topic as tools to confront potential confusion and misconception.

While the literature makes no claim to a hierarchal order of difficulty among the five components, it is, however, acknowledged from the descriptions, that the component of conceptual teaching strategies encompasses the understanding of the other aforementioned components. This renders the component highest in the order of difficulty. The understanding of common learner prior knowledge may be ranked least difficult as this could be similar to what teachers themselves experienced as learners (Kennedy; 1999).

METHOD OF DEVELOPMENT

Few considerations were made explicit prior to the development process. Like Carlson (1990), we acknowledged that clarity on the aim of the tool is important in order to determine its level. As our aim targets a large base of teachers, it was our view that the tool should adequately accommodate both novice and expert teachers. While this criterion may be viewed as given, its importance emerges in the selection and crafting of test items for the tool. The next issue considered was the care taken to only include test items that measured PCK. In our view, the ability to answer PCK items should require the understanding of specific content knowledge, combined with the knowledge for components of Topic Specific PCK described above. This view implies that the questioned person should have enough content knowledge of a topic in order to recognize the correct application of the pedagogical principle (Carlson, 1990).

Since we had established the conceptual framework of Topic Specific PCK in the earlier study (Mavhunga & Rollnick, 2011), the procedure for developing the tool followed chronologically from (i) confirming the characteristics of the test items fitting the Topic Specific PCK construct, (ii) production of test items, (iii) judgment of items (iv) construction of the instrument (v) piloting and (vi) validation of the instrument. The production of test items was challenging, as it required the strategic blending of specific content knowledge reasoned through the five knowledge components of Topic Specific PCK for various teacher related tasks. Teacher related tasks used in the tool include: assessing and giving feedback to learners, organizing concepts into main and subordinate ideas, sequencing of ideas, analysis for conceptual aspects regarded as difficult, adaptation of representations and making suggestions for teaching strategies for specified cases. The first test items generated were open ended in nature, capturing the responses through written responses. The items were subjected for judgement, to a reference group of 10 members, comprised of senior teacher educators, doctoral students in science education, and physical science teachers. It is in the critical review of the test items that the authors realized that not only should the examinee have topic specific PCK to answer the questions, but so should the examiner. Feedback from the reference team requested further refinement of the wording of the test items, removing ambiguity by adding specifications for the required response and the context of the given scenario, see Figure 1 below:

The format of the expected response specified

The format of the expected response specified

2. What comment would you write on a learner's script who writes:

A reaction reaches equilibrium when the concentrations of the products and reactants are equal.

Figure 1: Test item with specifications for context

Most of the pre and in-service teachers have English as their second language. The refined test items were pre-piloted with a small group of pre-service teachers, and formally piloted with a group of in-service teachers for language and considerations for duration of test. Based on the received responses and the recorded lengthy duration of 75 minutes for both cases, it was decided to frame the open ended questions into semi-closed questions with multiple choice responses to choose from, while allowing an opportunity for explanations and expansion of the choices made. Unlike content test items that may have a singular correct answer, the challenge lay in formulating responses bearing in mind that in teaching there is rarely a single correct way to do something, as shown in the extract in Figure 2 below.

CATEGORY A: LEARNERS' PRIOR KNOWLEDGE

1. What comment would you write on a learner's script who writes:

A reaction reaches equilibrium when the concentrations of the products and reactants are equal.

Response A: No; when a reaction reaches equilibrium it does not mean the concentrations of the reactants and products are equal. The concentration of reactants and those of products are not equal at equilibrium. Sometimes the concentration of reactants is more than that of products and vice-versa. It depends on the type of reaction.

Response B: No; when a reaction reaches equilibrium the concentration of the products and the reactants are not equal. Equilibrium is reached when both reactions proceed at the same rate.

Response C: No; the concentration of reactants and products at equilibrium are not necessarily equal. Each reagent may have its own concentration which is different to the other. What ensures a reaction to be at equilibrium is the rate at which the forward and the reverse reaction occur. For equilibrium to occur this rate must be equal for both reactions.

Response D: None of the above

Choose your response, and use the space below to expand on your choice.

Figure 2: Sample test item from the topic specific PCK instrument

Specific content areas covered by the tool on chemical equilibrium include: closed and open systems, dynamic nature of chemical equilibrium, equilibrium constant, disturbance of chemical equilibrium and the misapplication of the Le Châtelier's principle.

To score the Topic Specific PCK tool, a rubric similar to that in Park et al. (2010), corresponding to the five components was developed with each being rated on a four point scale, from 1('limited') to 4 ("exemplary"). The questions in each component were scored singly as an item, so the test comprised 5 items each with a maximum score of 4. A set of criteria for the component, learners' prior knowledge, is shown below in Table 1 as an example.

Table 1: Extract from the topic specific PCK rubric

Limited (1)	Basic (2)	Developing (3)	Exemplary (4)
*No identification, acknowledgement or consideration of student prior knowledge/ misconceptions	*Identifies misconception or prior knowledge *Provides standardized knowledge as definition *Repeats standard definition with no expansion or provides incorrect explanation	*Identifies misconception or prior knowledge *Provides standardized knowledge as definition *Expands and re-phrases explanation correctly	*Identifies misconception or prior knowledge *Provides standardized knowledge as definition *Expands and re-phrases explanation correctly *Confronts misconceptions/confirms accurate understanding

VALIDATION OF THE TOOL

The developed Topic Specific PCK tool was administered to two different physical science teacher groups: a group of 17 pre-service teachers in the final year of their teaching degree qualification, and a group of 10 qualified teachers whose experience ranged from 5 to 20 years.

The responses to the topic specific PCK instrument were scored using the rubric as described above. The rubric scores were peer validated by independent raters and an agreement rate of 80% was obtained. The raw scores were subjected to Rasch analysis, using the MINISTEP software, which entailed transforming them into probability measures that are on an equal scale (Bond and Fox; 2001). The Rasch model provides two reliability estimates, one for *persons* and one for *items*. The *person reliability index* indicates the replicability of person ordering we could expect if this sample of persons were given another set of items measuring the same construct (Wright & Masters, 1982). The *item reliability index* indicates the replicability of item placements along the pathway if these same items were given to another sample with comparable ability levels (Bond and Fox; 2001, p.32). *Validity* in the Rasch statistics model focuses on the idea that the recorded performances are reflections of a single underlying construct. Two indices of "fit" are provided by the Rasch software. One is called infit and the other is called outfit. Infit indices provide a statistic that reflects expectations of responses to item by specific persons. Outfit reflects items that are quite distant from a person's ability level (Boone and Rogan, 2005, p34). Item and measured person scores that fall within the statistic range of -2 and +2 are considered conventionally acceptable, and therefore indicate that the items and the person measures coherently work together to measure a single construct. The results below are analyzed as per the above described measures of reliability and validity understanding.

RESULTS AND ANALYSIS

The Rasch measure analysis reflected high reliability indices for both teacher groups as shown in Table 2 below. The high scores for person and item reliability in both groups indicate that the newly developed Topic Specific PCK tool has a good spread of measures across the continuum scale. That is, the tool is able to measure both low and high Topic Specific PCK measures with reliability. The high reliability indices further indicate confidence in the replicability of the scores with a comparable sample. The degree of internal consistency within the scores as reflected by the traditional statistics measure (Cronbach Alpha (KR-20) is acceptable for both groups. The fit of both the persons' measures and items' measures within the conventionally accepted range of fit indices -2 and +2, is a conventional indicator that the assumption that the tool measures a single construct dimension, Topic Specific PCK in this case, is empirically proven to hold.

Table 2: Person and Item Reliability Indices

Teacher Group	Person Reliability	Item Reliability	Cronbach Alpha (KR-20)	Fit Statistics (t = -2 and +2)
Pre-service	0.72	0.96	0.52	All scores
Experienced	0.95	0.90	0.92	All scores

The Rasch analysis allows the establishment of the difficulty rank order for test items and persons' ability, as shown in Table 3 below. The results show the five components of topic specific PCK were similarly ranked with a slight difference, where the Representation component is ranked almost equal to the Curriculum Saliency component for the experienced teachers.

Table 3: Ranking of components for the topic specific PCK instrument

Teacher Group	Learner Prior knowledge	What is difficult to learn	Curricular Saliency	Representations	Teaching Strategies
Pre-service	7.61	29.74	62.00	100.65	114.28
	<	<	<	<	<
Experienced	10.10	36.32	53.47	57.97	92.14
	<	<	≤	≤	<

The observed small difference may be attributed to the experience that in-service teachers have over the pre-service teachers. This calculated order of difficulty confirms the theoretical expected order discussed earlier. Such an agreement between the empirical and the theoretical expectation further confirms the validity of the tool (Wright & Masters, 1982, p.93).

DISCUSSION AND IMPLICATIONS

In formulating the test items for the Topic Specific PCK construct, it become clearer that, although the focus was not on SMK on chemical equilibrium, enough understanding of the topic was, however, needed as a base. The validity and the reliability indices of the tool have been found to be high and acceptable. Together, they indicate high confidence in the replicability of the newly developed tool. The findings are encouraging at the prospect of the value of the newly developed instrument. The implication further points to Topic Specific PCK being a valid theoretical construct that has been successfully conceptualized. Also, that an instrument to measure its quality quantitatively has been successfully developed and validated. While this study used chemical equilibrium as an example, research on extending the theoretical concept behind this tool to other topics in science is encouraged.

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Education to scientific images through chat supported collaboration to design functional brain images

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Abstract: Functional Magnetic Resonance Images result from a complex modelling process. Students have then difficulties understanding the meaning of these images, which are often used in the media with a reductionist approach. In a socio-constructivist approach, we offer students the opportunity to change their representations regarding these scientific models by asking them to collaborate at designing brains MRIs with the *EduAnatomist* software.

In this paper, we explore the relationships between students' interaction types, students' designs of scientific images and students' use of the scientific images to communicate. Data collected consists of software screenshots, slides designed by the students and MSN chats. The interaction types are analysed with Mercer (1998) talk analysis criteria. Moreover, we analyse the use of the software modelling parameters and the relevance of selected information to understand the image, to compare students' productions before and after interactions. Our results show that collaborative work needs time and that even if *disputational talk* could enhance the quality of the scientific images produced by the students, *exploratory talk* is strongly linked to collaborative knowledge production.

BACKGROUND, FRAMEWORK AND PURPOSE

Scientific images as cerebral Magnetic Resonance Images (MRI) are often used by the media with a reductionist approach and often support implicit values (Clément, 2001; Molinatti & Girault, 2007). Due to the complex process that goes into designing them, they are difficult to interpret. To design functional MRI (fMRI), scientists evaluate the variations of brain irrigation by measuring the magnetic resonance of each elementary volume unit of the brain (named voxel). They design subtractive protocols, making several measurements with and without the stimulus, and, using statistical tests, determine whether the difference between the two conditions is significant or not, for each voxel. On the fMRI obtained, the statistical values of the test are coded by the colour of the voxel. As a result, fMRI are both a model and a representation of the brain functions. Previous studies demonstrate that students have difficulties understanding the meaning of fMRI (Mafféo, 2007); thus, improving students' abilities to do so is a challenge for secondary science education.

Our research is based on the analysis of the uses of the software *EduAnatomist*, which allows one to design brain MRI images by downloading real data and choosing appropriate parameters. The main purpose of the learning sequence was to lead secondary students to understanding the status of brain fMRI images. We asked them to design fMRI and to communicate with these images. Our hypothesis was that collaborating to design scientific images would lead students to understand that brain MRI are not pictures of reality, but scientific models dependant on the designer's decisions. In this paper, we address the question of the impact of a collaborative work on the understanding of scientific images.

RATIONALE

Scientific images result from a modelling process. A brain MRI can be considered as a model that links theoretical assumptions on brain functioning and empirical evidence, as scientific models are intermediaries between theoretical and perceptual aspects (Bunge,1975; Sanchez 2008). Learning how to interpret scientific images also relates to the relationships between communication and learning, and can be approached by a socio-constructivist approach (Vygotski, 1934). Moscovici has theorized the link between communication and learning with the concept of social representations concerning the social circulation of scientific knowledge. *Social representations* are involved in "*the formative process and orientation process of social behaviours and communications*", but they are also updated during communication (Moscovici, 1961, p307). For this reason, collaborative learning may offer the students the opportunity to change their representations concerning brain functional images as scientific models. Indeed, collaboration implies construction of shared understanding through interaction with others (Dillenbourg, 1999) and thus brings about the co-construction of knowledge (Baker, 2002). Furthermore, many authors state that computer-supported collaborative learning contributes to students' conceptual and epistemological changes (Hakkarainen, 1998; Arvaja & al. 2008).

We coordinated the collaboration between students, which is defined by Arjava *& al.* (2008) as the engagement of participants in coordinated efforts to solve a problem or perform a task together. For Mercer (1996), this kind of interaction is characterised by "exploratory talk". Our research purpose was then to study relationship between students' interaction types (defined with Mercer talk analysis criteria), students' designs of scientific images and students' use of scientific images to communicate.

METHODS

EduAnatomist allows designing brain MRIs by downloading real research data and choosing appropriate parameters (appropriate section concerning each direction of the brain space, significance of the statistical test). During two hours learning sequence, two pairs of sixteen year old students were asked to work together to produce a slide for the school website. This slide included MRIs designed to explain how the brain is activated by 3 different tactile stimulations (for example, stimulation of tongue, foot and index). The collaboration had been previously prepared, using *EduAnatomist* to design and parameter the MRIs for 2 tactile stimulations. Students were asked to integrate this MRI in a slide containing all the information they thought necessary to be understood by other students.

The two pairs interacted by text messaging with MSN, sharing their previous productions for the design of their slide for the school website. Three different kinds of interactions were observed in this experiment: oral and direct interaction within the pairs of students, writing and distant interaction between the two pairs of students and writing interactions corresponding to the written information in the slide they were designing. This paper will focus on the text messaging collaboration phase between two pairs of students. Students were not allowed to communicate directly by showing their computer screens to one another. They had to formulate and explain their choices. Students had to imagine what the school website visitors would know and had to adapt their slides to make the images understandable.

The data that was collected encompasses software screenshots and slides produced by students before the chats, the text of the MSN chats and the slides produced by students during the chat. We quantified and qualified the interactions within the teams and explored theirs effects on the slides produced by students. The duration of the chat, the number of words and the number of interactions in each team were calculated. The argumentation was analysed using Mercer (1998) categories of talk: in *exploratory talk*, statements and suggestions are offered for joint consideration. These are challenged and counterchallenged with justifications and alternative hypotheses. In *cumulative talk* the participants build positively, but uncritically on what the other says. Knowledge is constructed by accumulation. *Disputational talk* is characterized by disagreement, competitiveness and individual decision making.

The modification of the students' productions during interaction was observed by comparing the slides produced before and after the pairs of students interacted. We referred to the learning objectives of the activity, which were the correct use of software modelling parameters to design an image that effectively shows the brain activated areas, and the identification of information needed to understand the image. The first objective was called *scientific value* and evaluated by identifying the number of cerebral areas effectively visible on the image in conjunction with the statistical parameters chosen by the students. The second objective was analysed by observing *caption relevance*, which refers to the number and kinds of caption added to the image. We also looked at what was modified, or not, or planned to be modified, in the slides by the students during chat sessions. Four sets of interaction between two pairs of students were studied in this experiment.

RESULTS

1) Types of interaction

Due to the difficulty in designing the images, the time devoted to chatting was shorter than we had planned. However, 3 groups had a quarter hour chat session (Table 1). Qualitative analysis of the chat sessions shows little argumentation leading to a firm conclusion. Student pairs 7B-8B were not involved in a real collaboration. They disagreed, made individual decisions and didn't work towards a common production (Table 2). Their chat consisted mainly of *disputational talk*. Student pairs 3B-5B (Table 3) were involved in a common task, through *cumulative talk*: they interacted positively but uncritically, saying "Why not?". They just accepted what was said by the others to build their proposition, without any critical thinking.

Interacting students' pairs	1B-2B	3B-5B	4B-6B	7B-8B
Chat's duration (min)	17:58	15:23	01:51	14:00
Number of interactions	21	30	4	19
Total of words	247	234	51	163
Statement without justification	6	1	-	3
Argumentation	5	2	-	3
Type of talk (Mercer, 96)	exploratory	cumulative	-	disputational

Table 1: Quantitative and qualitative analysis of the chats

Student pairs 1B-2B (Table 4) had a richer argumentation, with claims presenting data and explicit warrants (based on Toulmin (1969) argumentation model). Each of their suggestions was critically considered by the other; thus, their chat session shows an example of *co-argumention*. In regards to statistical parameters (the value of which can be chosen on the software within the bounds of two limits) 2B gave his choice, which 1B found too low, showing here a critical position. Then, they constructed together the argument leading to their common choice, one partner giving the ground and the other the warrant before the claim. When they tried to use this parameter, they formulated critical arguments ("can not take 70 ... there is nothing"). It shows that they collaborated to solve the problem (*collaborative talk)*.

7B	*What are your cursors ?*
8B	*inf 30 and sup 100*
7B	*It's not very clear. You must be higher where you put 30, to be more precise*
8B	*No, you choose too high value. Each to their own.*
7B	*No, no, teacher says it to us just now, and for us, it's very clearer*
8B	*Ba.. we don't give a fuck about*
7B	*Come on, start it again !*
8B	*No*

Table 2: Extract of chat between 7B and 8B students' pairs showing disputational talk (Translated from French).

3B	You want to replace command area with command area answering to the stimulation ?
5B	Yes, exactly man
3B	Da why not …

Table 3: Extract of chat between 3B and 5B students' pairs showing cumulative talk (Translated from French).

2B	*Top 32, down 100* (speaking of statistical requirement)
1B	*ok, but there's still quite a bit of error marging*
2B	*Yeah. We must take the same number* (warrant)
1B	*with 70 and 100 it is less important* (ground)
2B	*we take 70* (claim)
1B	*OK ...*
2B	*can not take 70 ... there is nothing ... we must take the same data*
1B	*Yes, we take less then, but should not have too low value… you can still go down, so try with 60 and 50*

Table 4: Extract of chat between 1B and 2B students' pairs showing exploratory talk (Translated from French, brackets for our own observations).

2) Effects of interaction on the students' productions

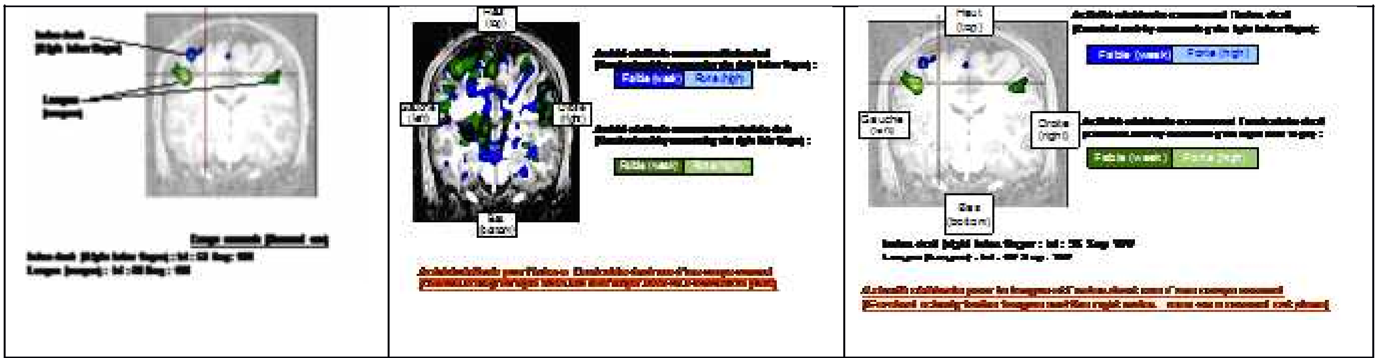
Multiple effects of these interactions on the students' productions were observed. For 3B-5B (Table 5), who had the same scientific value for their production before the chat, the interaction lead to an increase in the caption wealth, after they chose one of their productions.

Student pairs 1B-2B discussed a lot about the meaning of the statistical requirements and tried to produce a common MRI with the same statistical limits. We can notice that they had different scientific values before the chat. 1B selected high statistical parameters and displayed 2 areas, while 2B hadn't been able to find any effective cerebral area, because of its low statistical parameters. We can argue that the fact that they had very different productions at before their discussion lead them to interact more effectively, to criticize each other and to conduct exploratory talk. This was not the case for 3B-5B, who had the same type of scientific value for their previous productions and just performed cumulative talk. They worked on the captions, which were different in their previous slides, 3B's captions being richer than 5B's. The best production was chosen to begin the collaborative work.

Pairs 7B-8B had different types of production before the chat session. The two brain areas involved in tongue and index stimulations were clearly visible on 7B's fMRI, but only 4 elements were indicated in the title and caption (Figure 1). In contrast to this, the scientific value of 8B's production was bad, but the caption was very rich and elaborated. The large coloured areas displayed on 8B's fMRI (Figure 1) were not specific to the studied stimulation, because the statistical parameters were too low. During the disputational talk, 8B refused to modify their statistical requirements, but used 7B's slide to complement their own production, applying their caption on the high-valued scientific image produced by 7B. 8B didn't inform 7B and didn't send them the result. They just took advantage of the interaction for their own selves, in a sort of competitive way.

	Exploratory talk		Cumulative talk	
	1B	2B	3B	5B
Cerebral regions Statistical parameters	2 high	0 low	2 medium	2 medium
Caption elements	5	6	7	4
Discussed during chat	Statistical parameters		Caption	
Conserved elements	_		3B production	
Modified elements	Statistical parameters		Caption (2 elements added)	
Final production	Increase scientific value		Increase caption wealth	

Table 5: Analysis of students' slides



7B slide	8B slide	7B slide modified by 8B

Figure 1: slides produced by students before and after collaboration in an "additive way"

CONCLUSIONS AND IMPLICATIONS

One way to foster the understanding of MRIs can be the use of MRI visualization with software like *EduAnatomist*, which enables students to see the consequence of their choices of statistical parameters on the generated brain images. However, statistical thinking is difficult for students and concepts such as statistical tests or statistical comparisons must be understood before designing the images. The difficulties of understanding MRIs are also linked to the difficulty of visualizing the brain volume with plane sections and in transferring numerical statistical significations into coloured graduations. Therefore, it would be important to adapt the interface of the software to the students' level of knowledge and to the pedagogical objectives of the activity (Monod et al, 2011). Moreover, our experimentation brings to light the importance of the time devoted to implementing a collaborative work, especially if the concepts to learn are something as complex as the modelling of cerebral activity in functional MRIs.

Designing this type of scientific image by distant collaboration leads pupils to formulate and explain their choices. Within the few examples studied, we observed that pairs of students having different types of productions before the chat interacted with more criticism. If disputational talk can enhance the quality of the scientific images produced by the students, exploratory talk is linked to collaborative knowledge production and must be promoted. How can we foster collaboration and exploratory talk? Firstly, it is clear that much time is needed. Secondly, the pairing of students can be based on their previous productions (for example, associating students having different types of scientific value and caption value productions). This corresponds to the adaption of the script of an activit,y as promoted by Arvaja *et al*. (2008) and Dillenbourg & Jermann (2006). Structuring the students' communication and using tools to do so can also promote exploratory talk (Arvaja *et al*., 2008; Jermann *et al.*, 2004).

Designing scientific images for communication with peers is also a way to bring the students to reflect on the information needed to understand the image. In our experiment, students had to imagine what elements the school website visitors would know and had to adapt their slides to make the image understandable. In doing so, after setting the statistical parameters of the fMRI, they could perhaps realize that the fMRIs significance depends on their construction and modelling parameters, which leads to a better epistemological approach in regards to these scientific images.

Fostering a better understanding of MRIs is important, as the media, with a reductionist approach, puts forth disputable assertions in regards to these images. Further studies must be conducted to demonstrate that our modelling-based approach can change fMRI social representations. However, the use of software such as *EduAnatomist,* which implement scientific activities that are close to the real work conducted by scientists, is important. It offers to the students the opportunity to understand the core functioning of science.

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PEDAGOGICAL LINK MAKING: A METHODOLOGY OF ANALYSIS OF TEACHING AND LEARNING SCIENTIFIC CONCEPTUAL KNOWLEDGE

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Abstract: This paper provides an introduction to the concept of pedagogical link-making in the context of teaching and learning scientific conceptual knowledge. Pedagogical link-making is concerned with the ways in which teachers and students make connections between ideas in the ongoing meaning making interactions of classroom teaching and learning. We draw upon sociocultural perspectives to outline why we think that 'link-making' is fundamental to science learning and consequently to science teaching. We identify three main *forms of pedagogical link-making* and try to find some *pedagogical link-making approaches* associated with each of the three main forms. The resultant *framework* of link-making forms is applied in analysing a teaching sequence taken from a UK secondary school science classroom. Part of this analysis involves identifying specific *pedagogical tools/strategies* and *approaches* which might be employed in the classroom to support link-making.

Keywords: pedagogical link-making; scientific conceptual knowledge; teaching

INTRODUCTION

In this paper we introduce the process which we regard as being central to the teaching and learning of scientific conceptual knowledge, or indeed any other form of disciplinary subject matter: the *'pedagogical link-making'*. The idea of pedagogical link-making has arisen partly from our on-going programme of research on teaching and learning scientific conceptual knowledge (see, for example, Authors, 2003, 2006 and 2010), partly from scrutiny and analysis of relevant sections of the international research literature and partly from reflecting on our own teaching and learning experiences over the last thirty years. Pedagogical link-making is concerned with the ways in which teachers and students make connections between ideas in the ongoing meaning making interactions of classroom teaching and learning.

In this paper, we shall draw upon sociocultural perspectives to outline why we think that 'link-making' is fundamental to science learning and consequently to science teaching and identify three main *forms of pedagogical link-making*. We shall apply the resultant *framework* of link-making forms in analysing a teaching sequence taken from a UK secondary school science classroom and use this analysis as a basis for further reflecting on the key features of pedagogical link-making. Part of this analysis will involve identifying specific *pedagogical tools/strategies* and *approaches* which might be employed in the classroom to support link-making.

THEORETICAL FRAMEWORK

Link-making for teaching and learning scientific conceptual knowledge

The idea that learning conceptual knowledge involves the learner in making links between their existing knowledge and new ideas is a basic assumption of constructivist perspectives on learning (see for example, Larochelle et al, 1998). The same is true for sociocultural accounts of learning where Vygotsky (1987) sees learning scientific conceptual knowledge as entailing a passage from social to personal planes through a process of internalisation. The internalisation step does not involve the learner in absorbing knowledge 'fully formed' from the interactions of the social plane, but involves a process of individual *reconstruction* as the learner makes sense of new ideas in terms of their existing ones. In this way learning or meaning making is regarded as being an essentially dialogic process which involves bringing together and working on ideas.

Thus coming to understand an idea involves bringing into contact new and existing ideas; it involves *making links* between new and existing ideas as we match the speaker's word with a counter word, with the depth and extent of understanding depending upon the number and quality of the links made. Put simply, the teacher must address link-making on the social plane of the classroom in order to support students in constructing similar links for themselves on the personal plane.

In our analysis we shall relate the link-making process with the four classes of communicative approach (Authors, 2003), which are defined by categorizing the talk between teacher and students along two dimensions. The first dimension represents two forms of interaction, dialogic and authoritative, whilst the second dimension involves the distinction between interactive and non-interactive talk. For the first dimension, dialogic communication involves teacher and students paying attention to more than one point of view, more than one voice is heard, and there is exploration or 'interanimation' (Bakhtin, 1981) of ideas. In general terms, dialogic discourse is open to different perspectives. Alternatively, in authoritative communication attention is focused on just one point of view, only one voice is heard and there is no exploration of different ideas. For the second dimension, the talk can be interactive in the sense of involving the participation of more than one person, or non-interactive in the sense of involving the participation of only one person, which is usually the teacher. The two dimensions combine to generate four classes of communicative approach: Interactive/dialogic, non-interactive/dialogic, interactive/authoritative and non-interactive/authoritative.

Three forms of pedagogical link-making

Starting from basic principles of teaching and learning, we have identified three forms of link-making. The first entails making connections between different kinds of knowledge to support students in developing a deep understanding of subject matter. We refer to this as pedagogical link-making to *support knowledge building*. The second form of link-making follows from the fact that both learning and teaching, by their very nature, are played out over a period of time, involving days, weeks, months, years. Consequently, if deep learning is to be the outcome, there is the need to make links between teaching and learning events occurring at different points in time thereby promoting a form of intellectual continuity (Mercer, 2008). We refer to this as pedagogical link-making to *promote continuity*. The key feature of links to promote continuity is that they involve making references to teaching and learning activity across points in time. The third and final form of pedagogical link-making, which we have identified, is rather different in kind to the first two and relates to the different ways in which the teacher makes links to encourage a positive emotional response from students to the ongoing teaching and learning. We refer to this as pedagogical link-making to *encourage emotional engagement*.

THE METHODOLOGY AND THE CASE STUDY

We applied the framework to a particular case, articulating the four classes of communicative approach to different approaches and strategies used by the teacher to promote link-making. The case study focuses on a short sequence of five science lessons with a mixed ability year 7 (students about 12 years old) science class in a state secondary school in a semi-rural setting in the North of England. The teacher is a science specialist with about 20 years teaching experience and is highly regarded in the local science teacher community and is, by any standards, an expert teacher. The aim of the lessons was to provide an introduction to a school science view of four specific kinds of force: tension, gravity, normal force (also referred to as the 'up-push' by the teacher) and friction. The case study focuses on the way in which two of the content themes were addressed in the lesson sequence. These are the 'normal force' and representing forces through an arrow (force vector) notation. The teaching and learning of both of these themes took place over three consecutive lessons.
The lessons were video taped with one camera and the teacher was interviewed after each lesson. We also conduct interview with some of the students after the five lessons. We segment the video in episodes. Our definition of episode is an adaptation of the definition of event in the interactional ethnography tradition. Therefore, an episode is defined as a coherent set of actions and meanings produced by the participants in interaction which have a clear beginning and end and can be easily discerned from the previous and subsequent episodes. Usually this distinct set is also characterized by a specific function in the flow of discourse. Border markers between the episodes include verbal and non-verbal aspects. The contextual cues referred to by Gumperz (1992) include proxemic (related to the orientation between the participants) and kinaesthetic changes (related to gestures and body movements), changes in intonation, emphasis, topic or theme, genre, pauses, etc. These cues permit the precise determination of the frontiers of each episode in the flow of time.
After segmenting the video in episodes and making a map of episodes we qualitatively analyse the episodes trying to identifying all the links made on each specific episode.

RESULTS

For each of the three forms of pedagogical link-making we identify different pedagogical link-making approaches in our date. For the form 1 – *support knowledge building* – we identify the making of links between: 1) everyday and scientific ways of explaining; 2) scientific concepts; 3) scientific explanations and real world phenomena; 4) different modes of representation; 5) different scales and 6) analogous cases. For the form 2 – *promote continuity* – we identify the making of links related to the development of the scientific story and to the management/organisation of the class. These links were made through three different time scales: macro, meso and micro. For the form 3 – *encourage emotional engagement* – we found two main approaches: one which addressed substantive content of the lessons, whether by linking to ideas or by linking to contexts/phenomena, which we called pedagogical approaches; and the other involving strategies of encouraging people to participate in the lesson, which we called generic approaches.

We shall give examples of each of the approaches indicated here and describe how the link-making framework can give evidence of the learning process. It is clear that if link-making is not addressed through teaching then it is unlikely to emerge in students' learning. From this perspective, then, both teaching and learning must involve link-making processes: they are the complementary sides of the same pedagogical coin.

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AN INTERVENTION FOR USING MULTIPLE REPRESENTATIONS OF MECHANICS IN UPPER SECONDARY SCHOOL COURSES

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Abstract: Previous research has emphasized the importance of multiple representations for learning and understanding physics concepts. Students should learn to construct multiple representations of physical processes and learn to move in any direction between these representations. For this purpose, we designed teaching material emphasizing multiple representations within the context of forces. The material and short instructions (= intervention) were given to two experienced upper secondary school teachers who were not involved in designing the intervention. They used the intervention material in their mechanics courses in fall 2009 (students *n*=28 altogether). The effect of the intervention on the learning of forces and representations was evaluated using a multiple-choice test Representational Variant of the Force Concept Inventory (R-FCI) as a pre- and post-test. In addition, students' answers to exercises of the intervention material were copied and collected. All lessons were videotaped and the teachers were interviewed after the course. The results were compared with the R-FCI baseline data (*n*=22 altogether) collected prior to the intervention from the same mechanics course taught by the same teachers in fall 2008. Our results suggest that the intervention material was useful for students' learning of the force concept and multiple representations.

Keywords: Multiple representations, mechanics, force, intervention

INTRODUCTION

This study concentrated on multiple representations of upper secondary school physics in the context of Newtonian mechanics. The focus was on external representations (e.g. graphs and vectors) as distinct from internal, mental representations. In the school context, external representations can be seen as communicative tools between a teacher, students and media (e.g. books), and also as cognitive tools when students are working alone, for example, in problem solving. Instead of processing everything internally in their minds, they can create an external representation and thus reduce the cognitive load (Schnotz, Baadte, Müller, & Rasch, 2010).

Multiple representations refer to the circumstances where various representations are used for learning a concept or solving a problem instead of, for example, only verbal and mathematical representations. Multiple representations have many functions in learning (Ainsworth, 1999). They can complement and constrain other representations, and construct a more complete understanding. According to Van Heuvelen and Zou (2001), multiple representations are useful in physics education as they foster students' understanding of physics problems, building a bridge between verbal and mathematical representations, and helping students develop images that give meaning to mathematical symbols. These researchers argue that students should be taught to construct multiple representations and to move in any direction between these representations. Furthermore, studies in physics education research have shown that the representational format in which a problem is posed significantly affects student performance (Meltzer, 2005; Nieminen, Savinainen, & Viiri, 2010).

A natural resource of multiple representations in studying physics would be a textbook, which indeed plays a central role in teaching and learning in Finland (Korkeakoski, 2008). Textbooks have been constantly revised in accordance with the present curriculum. Generally teachers follow the structure of textbooks and they use textbook-based exercises for class- and homework. Finnish students have become accustomed to studying with textbooks. Whilst we are aware that Finnish textbooks draw on standard representational formats used in physics, they do not necessarily offer many exercises that stress the use of multiple representations.

There is some research in science education on how evidence-informed teaching interventions can be transferred to teachers who have not been involved in designing the interventions (Leach, Scott, Ametller, Hind, & Lewis, 2006). As pointed out above, the emphasis on multiple representations in teaching and learning is important for understanding physics. However, we were unaware of any studies in which multiple representations-based teaching interventions are implemented by transfer teachers in upper secondary school. In order to study this we designed an intervention that stressed the use of multiple representations in the context of force and conducted a study concerning the use of this intervention in two upper secondary school mechanics courses taught by two transfer teachers. We hypothesized the intervention could enhance students' learning when implemented by transfer teachers.

The research questions were:

1) How did the transfer teachers integrate the intervention into their teaching without any extra training?
2) How did the intervention affect students' conceptual understanding of force and their ability to interpret multiple representations?
3) What kind of textbook exercises were used from the perspective of multiple representations?

METHOD

Design and experiment of the intervention

This paper mainly describes the intervention and baseline phases of the study, however each phase (Fig. 1) is briefly presented. The intervention material itself was designed during the design phase. The material consists of seven exercises (3–6 sub-items per exercise). These open-ended, paper-and-pencil exercises emphasize the use of multiple representations and guide movement between the representations in different contexts that address the force concept. During the pilot phase, the material was used in an upper secondary school course taught by one of the authors (AS). After the pilot phase we made some improvements to the material. Only the research group (the authors) participated in these three phases.

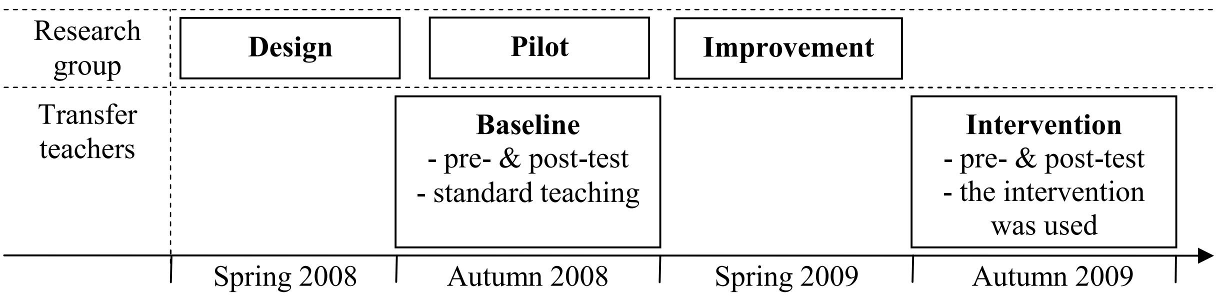


Figure 1. Different phases of the study

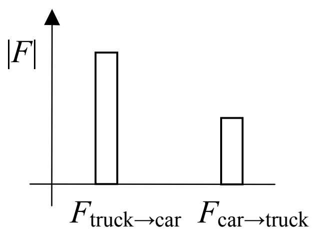
The baseline phase was required to evaluate the influence of the intervention on students' learning. Between the baseline and intervention phases, the teachers remained the same, as did the courses within the same high school mechanics courses. The only difference was that the intervention was not used in the baseline phase and, of course, the different year groups contained different students.

During the intervention phase, we gave the intervention material to two transfer teachers. We did not want to interfere too much with the teachers' plans for the course, hence we only made suggestions about when to use a certain exercise during the course in relation to the content of the course. We did not provide instructions on how to use the material.

Pre- and post-test instrument

For evaluating students' understanding of the force concept and the ability to interpret multiple representations consistently (i.e. *representational consistency*) the Representational Variant of Force Concept Inventory (R-FCI; Nieminen et al., 2010) was used. The R-FCI contains nine *themes* concerning gravitation and Newton's laws in different contexts. Each theme has three isomorphic items (the context and content remain as similar as possible) in different representations. Each item contains five multiple-choice alternatives: one scientifically correct and four incorrect distracters. Figure 2 provides an example for corresponding alternatives of the items of a theme. A more detailed description of the R-FCI is provided in our previous article (Nieminen et al., 2010).

Item #2, alternative (d).



Item #11, alternative (a).

The truck exerts a greater amount of force on the car than the car exerts on the truck.

Item #20, alternative (c).

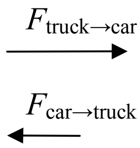


Figure 2. Corresponding multiple-choice alternatives of the items of a theme of R-FCI

The R-FCI was used to evaluate representational consistency. When a student exhibits representational consistency, scientific correctness is not required. Figure 2 shows an example of one representationally consistent answer pattern in which each item has been answered scientifically incorrectly. Of course, if a student answers all three items of a theme correctly, he/she also exhibits representational consistency as the selected alternatives correspond between the items.

The R-FCI score (sum of scientifically correct answers) can be used for evaluating students' conceptual understanding of force. The pattern in Figure 2 exhibits no conceptual understanding: each item has been answered scientifically incorrectly and answering this way does not increase the score. Instead, answering each item of the theme correctly would add three points to the total score. It should be noted that understanding a representation is required to solve a conceptual problem with that representation. Hence the R-FCI score, as a measure for conceptual understanding, is not independent of the understanding of representations. However, there are strong correlations between R-FCI and FCI scores indicating that the R-FCI score is appropriate for evaluating conceptual understanding of force (Nieminen et al., 2010).

Participants and data collection

Both transfer teachers had over 10 years, and therefore extensive, experience in teaching upper secondary school physics. The students (aged 17) were taking their fourth physics course (mechanics, 30 lessons, 45 mins per lesson) in autumn 2008 (baseline courses, *n*=22 altogether) and 2009 (intervention courses, *n*=28 altogether). Each student took the R-FCI as a pre- and post-test. In the results section, we have referred to the schools as School1 and School2, and the teachers as Teacher1 and Teacher2 respectively.

During the intervention phase each lesson was videotaped and the teachers were interviewed after the course. The intervention students' answers for the intervention exercises were collected before the teacher gave the correct answers. We did not, however, get all of the intervention students' answers for all of the seven exercises. The exercises were given at different points during the course and some students were not in school on certain days or did not complete the exercises for one reason or another. In the analysis of the intervention exercises we have included students (*n*=21) who completed 4-7 of the exercises. The baseline students did not complete the intervention exercises at all.

Video-data analysis used Atlas.ti software and PASW Statistics 18 was used for the quantitative analysis of R-FCI data and intervention exercises. To evaluate the conceptual understanding change we used normalized gain (Hake, 1998) defined as the ratio of the actual gain to the maximum possible gain:

$$< g >= \frac{\text{Post - test \%} - \text{Pre - test \%}}{100\,\% - \text{Pre - test}}$$

Normalized gain is independent of students' pre-instruction score of measured variable, useful for the comparison of student groups. Normalized gain can be calculated from class averages (average normalized gain) or single-student scores (single-student normalized gain). This study used the latter for statistical comparisons of student groups and correlation analysis.

RESULTS

Implementation of the intervention

Both teachers used the intervention exercises as homework: They gave an intervention exercise to students as homework and they presented the correct answers at the beginning of the next lesson. Hence, the teaching time used for the intervention was very limited: 7% in School1 and 4% in School2.

There were differences, however, in how the teachers talked through the solutions of the exercises: Teacher2 only showed the correct answers, whereas Teacher1 elicited the correct answers from the students. On the other hand, Teacher2 criticized some exercises and our example solutions. Both teachers closely followed our suggestions as to when to use a certain exercise, albeit that the final exercise #7 was not completed in School2 at all. Most of the time, interaction between students and the teacher was minor or non-existent in both courses and teacher presentation was the dominant activity in class. Teacher2 gave much more time (39% of teaching time) to student work without his involvement than Teacher1 (only 6%).

Text book exercises in the intervention courses

School1 used a different textbook than School2 (School1: Lehto, Havukainen, Leskinen, & Luoma, 2006; School2: Hatakka, Saari, Sirviö, Viiri, & Yrjänäinen, 2005). Each textbook exercise used for class- or homework was analysed. We found that 77% of the textbook exercises in School1 were presented via verbal format (text) only. The other exercises (23%) also included one other representation: a graph, a picture or a table. In School2, 50% of the exercises were in verbal format only, and 48 % also included a graph, a picture, a table, vectors, or a motion map. One exercise (2%) included verbal, pictorial and graphical representation. Many exercises included mathematical markings, such as 7 m/s, but no exercise included equations, for example $F=ma$. This analysis did not concentrate on which representations were demanded for solving the exercises, but only which were presented on the textbook page.

We also categorized the textbook exercises as quantitative (calculations were needed in the solution) or qualitative (no calculations). In this categorization, a certain quantitative exercise may contain some qualitative characteristics, but a qualitative exercise does not contain any calculations. Table I shows that the most of the exercises were quantitative in School1 (81%) and School2 (63%), but these were more frequently employed in School1. The majority of exercises (67%) were quantitative in verbal representation in School1. This was the most general type also in the School2, however less frequent there (39%). Qualitative exercises were performed more frequently in School2 (37%) than in School1 (19%). In particular qualitative exercises which included verbal and one other representation were more common in School2.

Table I. Classification of textbook exercises in School1 and 2. Some of the exercises were expressed via *only verbal* representation and the other exercises via verbal and one other representation (*verbal* +). *One exercise (2%) included verbal and two other representations.

		Quantitative		Qualitative	
School	Number of exercises	Only verbal (%)	Verbal + (%)	Only verbal (%)	Verbal + (%)
1	58	67	14	10	9
2	62	39	24*	11	26

Conceptual understanding of force

On average the normalized gain was higher among the intervention than baseline students in both schools (Table I), but the differences were not statistically significant. However, for all students (School1&2) the nearly significant p-value (.077) and the effect size of .56 suggested that the learning outcomes were better among intervention students than baseline students (medium $d\approx0.5$; (Cohen, 1988).

We studied the students' answers to the intervention exercises and found various misconceptions (e.g. impetus or dominance conception) and errors in the use of representations. We also graded the correctness of students' answers and found that the students' (n=21) intervention exercise scores correlated with students' normalized learning gain (ρ=.50, p=.022). Hence, the R-FCI and intervention material seem to evaluate the same content and skills at least to some extent.

Table I. Normalized gain and standard errors (parentheses) in different student groups. For differences between gain of intervention and baseline groups Mann-Whitney U-test was conducted and Cohen's effect sizes calculated.

	Intervention course		Baseline course		For gain differences	
School	Gain	n	Gain	n	p-value	Effect size (d)
1	.39 (.08)	16	.19 (.10)	13	.18	.58
2	.47 (.08)	12	.27 (.17)	9	.39	.50
1&2	.42 (.06)	28	.22 (.09)	22	.077	.56

Representational consistency

The pre-test representational consistency did not differ between the intervention and baseline course students (Fig. 3): for the intervention students representational consistency was 76%

and 75% for the baseline students (School1&2). The post-test consistency, in contrast, was higher among the intervention students (83%) than the baseline students (78%), although the difference was statistically almost significant (Mann-Whitney U-test, z=1.71, p=.088).

With regard to the baseline students, there was no significant change in representational consistency (i.e. the difference between pre- and post-test; Fig. 3). With regard to the intervention students, this change was significant (Wilcoxon Signed Rank Test, z=2.80, p=.005). The change was greater in School2 than in School1. In School2, the change of representation consistency was significant for both the intervention (z=2.68, p=.007) and baseline students (z=2.07, p=.038), but it was clearly greater for the intervention students as the effect sizes also indicate (1.25 and .33 respectively). In School1 the change was not significant among intervention or baseline students. The intervention students of School2 exhibited more representational consistency in post-test than the intervention students of School1 (z=2.37, p=.018).

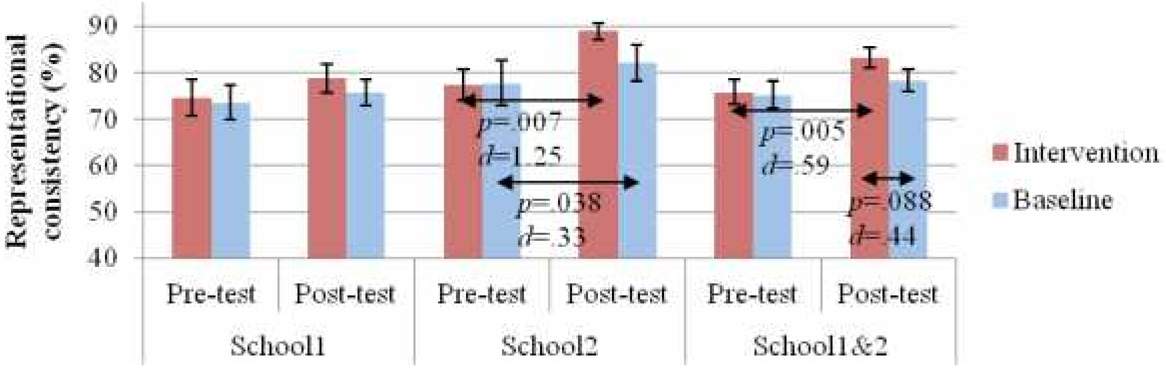


Figure 3. Students' representational consistency in intervention and baseline groups

DISCUSSION AND CONCLUSIONS

The first research question asked how transfer teachers integrated the intervention in their teaching without any extra training. The teachers received no instructions on how to use the intervention material. Both teachers used the material as homework exercises, limiting the teaching time used for the intervention in both schools. The teachers had taught the mechanics course many times before, and they said in the interviews that they had not changed their teaching with the exception of including the new homework exercises (intervention material).

The second research question concerned the effect of intervention on students' conceptual understanding of force and their ability to interpret multiple representations. Despite the lightness of the implementation, the results suggest that the intervention increased students' understanding of force (medium effect sizes for normalized gain of the R-FCI score). In addition, the change of the representational consistency was greater for the intervention students than baseline students, especially in School2. The intervention was used only in the two courses with the small amount of students hence one needs to be careful with the generalization of results to a bigger population. A replication study in other courses and schools would be of value.

The third research question asked what kind of textbook exercises were used from the perspective of multiple representations. We assumed that if the intervention material contained something that the textbook exercises did not include, such as the use of multiple representations and qualitative thinking with regard to forces, this could explain some of the increase of intervention students' learning. Indeed, especially in School1, textbook exercises included few multiple representations and mainly focused on calculation. In School2 exercises contained more representations. Qualitative exercises, which did not demand calculation, were also used more in School2.

Why did the intervention students in School2 seem to benefit more from the intervention than their peers in School1, especially when the textbook exercises of School1 included only a few representations? Maybe School2 students were more accustomed to studying with representations: the students had used the same textbook series in their former physics courses. Or perhaps School2 students benefited from both the intervention material and the multiple representation exercises of the textbook. It should, however, be emphasized that differences between the schools can be caused by many other reasons than just the intervention material. Nevertheless, the material seemed to improve learning in both schools.

The results from this intervention support the assumption that the use of multiple external representations benefits student learning. The ease with which the transfer teachers integrated the material also suggests that this "transfer approach" can be more widely introduced without too much difficultly. Furthermore, the positive results with this light intervention may well suggest that this type of approach could be used more extensively to support student learning.

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GENETIC ENGINEERING EDUCATION AND CITIZENSHIP IN TUNISIA

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Abstract: This study focuses on a particularly "hot" scientific topic, genetic engineering. This cross- cutting science technology is rolling continuously. It is situated in the crossroads of three big fields of research: the STS, the SSI and the QSSV. Its uncertain implications give rise to heated discussions on the research, media and society level. This is why special attention should be given to ways of putting into practice didactic strategies appropriate to this type of knowledge. Considering the teacher's role in the educational process and the management of the relation knowledge-student, we focus on Tunisian professors' practices in authentic class situations. Through the analysis of the classes and that of the exchanges between teachers and students we try to determine if the subject matter and the way it is taught would allow for the development of the personality and the education of the Tunisian students' as a citizen. However we succeeded to show that the management of the knowledge to be taught by the observed professors doesn't promote this type of education and isn't in adequacy with the nature of this scientific topic.

Keywords: genetic engineering- Tunisian professors' practices- authentic class situations- citizenship

THEORETICAL APPROACH

The teacher has a major role in the teaching/training process. He determines the relationship between the student and knowledge. He organizes the contents of the course and follows the appropriate didactic strategies. This makes his task complex and delicate especially when it deals with a yet unfinished knowledge and social topics such as genetic engineering.

However, in this process, the shifts cannot be excluded, the teacher being a complex person with emotions and representations rooted in his individual and social history. He is present in the didactic situation with his own ideology and his private representations (Joshua & Dupin, 1993).This could have an effect on his way of acting in the classroom, on the processing of the contents to be taught, on his way of interacting with the pupils and thus on their performances. In this regard, the science didactic research showed that the teacher's influence on the pupils' performances is more important than that of the textbooks or teaching strategies (Welch, 1969 quoted by Simonneaux, 2005).

Moreover, the intellectual tools for constructing knowledge are acquired through verbal exchanges. The language plays an important mediating role in the learning process and the teacher occupies a major position in the organization, the management and the dynamics of the interaction in the classroom. In this perspective, several studies have been directed towards the analysis of the dialogue between teacher and student, in the didactic situation.

Rogalski (2006) shows that the piloting of the class is essentially made through the speech of the teacher ; Sarrazy (2001) underlines the role of the didactic interactions of the professor in the process of teaching and the functions which they assure the advancement of the knowledge.; Mortimer and Scott (2003) show that the students' learning process is influenced by the structure of the speech in class ; others provide that the outline and the contents of the interactions allow to report and to differentiate the practices of the teachers (Dunkhin and Biddle, on 1974; Altet and *al* ., 1996, quoted by Clanet, 2005) …

Consequently, we decided to study the didactic practices of Tunisian teachers through their verbal interactions with the students and their contents processing of the knowledge to be taught. We speak of didactic practices as far as they aim directly at the genetic engineering teaching / learning. Our main research question is the following:

> Do the proposed contents, their management by the professors, the structure of the joint action between the professors and the students, and the communicative approach(s) adopted by the teachers, contribute to the education of future citizens?

METHODOLOGY

We observed and audio recorded eight natural science teachers in real situations while teaching genetic engineering in the final year of the high school. The recordings were entirely transcribed.

We opted for a multi-referenced analysis in details, as far as the crossing of the various approaches could enlighten us more on the didactic practices of the teachers and the real curriculum in class. Our analysis contains three levels:

> The macroscopic level: cutting the corpus in steps to follow the dynamics of the teaching process, to reflect different themes as they progress and to develop an overall frame of the lesson.
>
> The mesoscopic level: cutting the steps in didactic games to determine a synopsis for every session of the course. The various

realized "games" are described to compare the contents processing by various teachers.

The microscopic level: it contains three steps:

*First, determining the structure of the joint-action (professors-students) by analyzing the management of the *chrono, meso* and *topo* geneses by the teachers (Sensevy, 2007; Schubauer-Leoni & *al.* 2007).

*Then, characterizing every didactic "game" by using the quadruplet: *definition, regulation, devolution, institution knowledge* (Brousseau, 1986);

*Finally, analyzing the games according to the communicative approach which is particularly centered on the discursive practices of the teacher (Scott and Mortimer, on 2003).

We limit ourselves, in this presentation, to the méso and microscopic levels. We study the contents processing of the knowledge to teach as well as the data obtained from the three analytical approaches quoted above.

We postulate that this type of analysis would favor a complementarity between the various approaches and would allow to report the way according to which the observed teachers manage the development of the teaching/learning process and interact with their pupils.

RESULTS

The results obtained are:

**In the mesoscopic level*

1. The genetic engineering applications are not handled by all the teachers.
2. The ones that are mostly brought up are those with medical purpose. They are perceived only according to their positive aspects.
3. The observed teachers handle neither the social stakes of the genetic engineering knowledge, nor its limits, nor the repercussions of its applications.

**In the microscopic level*

1- Determining the structure of the joint action (teacher-student) shows that the management of chrono, meso and topogeneses is operated by the teacher. He positions himself as a regulator of knowledge. He holds a position based on the development of scientific knowledge and advanced didactic time.

2- Characterizing the games according to the quadruplet of Brousseau (1986) shows that the tasks are rarely defined and never devolved to the students. Besides, the teacher is the one to regulate the knowledge construction.

3- The communicative approach confirms the results obtained from both previous analyses. It reveals certain constants in the management of the knowledge by the teachers:
- Dominance of the exchange patterns from types (Question-Answer) and (Question-Answer-Evaluation) piloted only by the teacher. He is the only one to initiate questions.

- Dominance of an authoritative pseudo interactive or non interactive model, where the teachers position themselves as administrators of the activities. They students are not involved in the knowledge construction. This does not prepare them for citizenship. These teachers focus on the development of the scientific knowledge and even if they are sometimes interacting, these interactions are pseudo interactions to advance the didactic time.

- The dialogical model is almost absent.

CONCLUSIONS

Finally, we can conclude that the contents proposed by the teachers become integrated into a descriptive approach of the genetic engineering techniques, disregarding its multiple applications and social implications of this QSSV.

The dominance of the authoritarian approaches (interactive or not interactive) observed at the teachers end, as well as the carriage they adopt don't involve the student in the teaching / learning process.

We think that discussions held in class about QSSV could increase the interaction between the teacher and the students. This would help moving away from authoritative/non-interactive postures towards a communicative model more emancipated, responding to a dialogical/interactive approach and taking into account the diversity of the students' ideas and their conflicting points of view. Feeling involved in the process of building the knowledge the students will be more motivated to address and discuss issues of broad scientific interest.

Thus we could contribute to the education of capable and informed future-citizens: "to develop a clear opinion regarding these questions, to be able to make choices in terms of prevention, action… and to be able to discuss them." (Simonneaux, 2010, p.)

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USING COMMUNICATION PATTERNS FOR ANALYSING CLASSROOM ACTIVITIES IN CHEMISTRY

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Abstract: The presented study is part of the project ProwiN (Professionswissen in den Naturwissenschaften – professional knowledge in science) that explores three dimensions of professional knowledge in science: content knowledge (CK), pedagogical content knowledge (PCK) and pedagogical knowledge (PK) of chemistry teachers. The central aim of this study is to investigate the correlation between PCK and chemistry teachers' classroom activities. For this purpose, a theory-driven category system based on the standards of content analysis is being developed in order to analyse videos of chemistry lessons. This study is predominantly concerned with the analysis of communication patterns between teachers and students. The central aim is to discern how teachers deal with their students' misconceptions. Therefore 25 videos of chemistry lessons available from an earlier video study is analysed with the help of communication process diagrams. Examples of our new developed communication process diagrams as well as results from the first study are presented.

Keywords: pedagogical content knowledge, video category system, classroom activities, students' misconceptions, communication patterns

INTRODUCTION

Both teachers' knowledge and teachers' classroom activities have become focal points in science education research (Baumert, Kunter, Blum, Brunner & Voss et al., 2010; Stigler, Gonzales, Kawanaka, Knoll & Serrano, 1999). One major deficit in chemistry instruction research is seen in the lack of studies that correlate teachers' PCK and teachers' classroom activities (Abell, 2007; Lipowsky, 2006). To that end, advantages of video analysis become obvious. Thus, the main goal of this current study is to develop a video category system in order to evaluate chemistry teachers' PCK while focusing on students' misconceptions.

The main variables that determine successful teaching are (1) the teacher and (2) his or her professional knowledge. Following Shulman's concept of professional knowledge (1987), a theoretical distinction is often drawn between pedagogical knowledge (PK), content knowledge (CK), and the knowledge needed for teaching a specific subject: pedagogical content knowledge (PCK). The presented study is part of the larger project ProwiN that examines these three dimensions of professional knowledge in science, assuming that they influence chemistry instruction and enable us to draw inferences about students' learning outcomes. Although several conceptualisations of PCK have already been developed, there is no generally accepted definition of PCK (Kind, 2009). However, two facets can be seen as key elements of PCK: knowledge of representations and strategies and knowledge of students' misconceptions (Van Dijk & Kattmann, 2010). This study is solely concerned with students'misconceptions/preconceptions.

The interest of scientists in students' ideas and especially in their misconceptions came to prominence at the end of the 1970s and in the early 1980s. Misconceptions mean any concept that differs from the commonly accepted scientific understanding of the concept (Nakhleh, 1992).

The essential purpose of the study is to explore how teachers deal with their students' misconceptions. To do that, communication patterns in the classroom are closely analysed. Pitton (1997) identified typical communication patterns in chemistry lessons: One major pattern is that teachers tend to ask narrow, leading questions and therefore impede qualified statements from their students.

Fundamental to this project are the following research question and hypothesis:

Q1: Is there any difference in terms of communication patterns between chemistry teachers with a high score in the PCK test and those with a low score in the PCK test?

H1: Chemistry teachers with high PCK provide their students more often with the possibility to give reasons for their statements in communication processes than chemistry teachers with a low PCK.

METHODS

For this study, 40 lessons of chemistry teachers will be videotaped. Therefore, a theory-driven category system based on the standards of content analysis is being developed in order to analyse videos of chemistry instruction that focus on students' misconceptions (Bos & Tarnai, 1999). To explore the instructional surface structure (e.g. organisational elements of the lessons) and the deep structure (e.g. teachers' perception of students' misconceptions), low and high inferent categories are designed. Referring to Bos & Tarnai (1999), the development of the coding system can be subdivided in five central steps. On the basis of the theoretical background and research question (step 1), observation categories are identified and category systems are constructed (step 2). These categories are described by an operational definition in a coding manual with rules and indicators referring to both, theory and video data. The categories are repeatedly checked, corrected, and modified. In a further step (step 3) called training session, three coders independently analyse a set of video lessons with the help of the written instruction. There are two ways of realising the video coding process. One method is to watch 10 seconds of the clip, code all variables, and go on with the next 10-second interval (time sampling). In a second type, a clip keeps running until the coder gives an explicit signal to end the coding (event sampling). The coder training in step 3 is completed when the coders reach a direct observer agreement of 60 to 75%. In this study an event based coding is used. Step 4 focuses on the analysis of the data. Finally (step 5), the results are interpreted in reference to the theoretical research questions (Bos & Tarnai, 1999; Janik & Seidel, 2009; Olszewski, 2010; Seidel, Prenzel & Kobarg, 2005). In this study, teachers' PCK is assessed by using a test that has already been developed (Witner & Tepner, 2011).

During the development of the observation tool, a theoretical model (Figure 1) for comprehending the surface and deep structures of instruction is also designed. This model represents concise qualified students' statements:

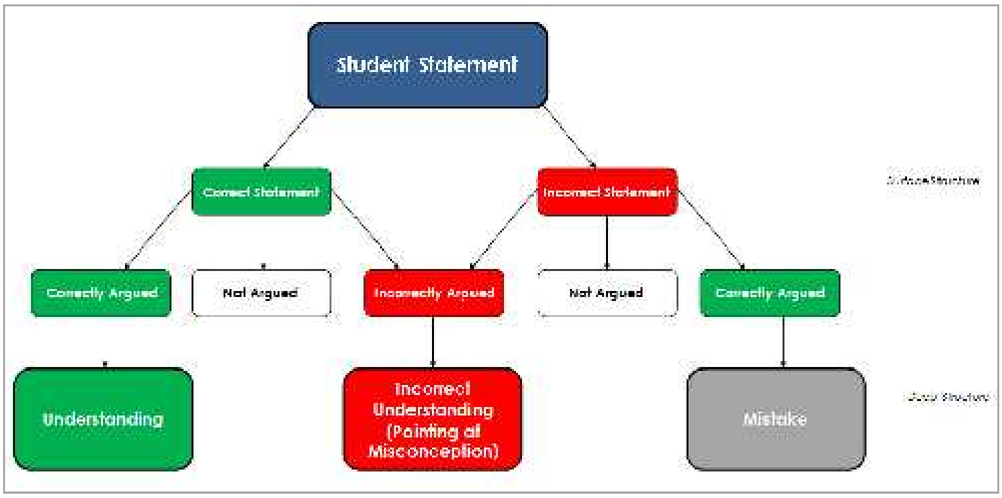

Figure 1. Theoretical Model

To refine this model, video material of 25 chemistry lessons is being analysed with the help of communication process diagrams. The videos belong to two different groups of classes of a grammar school (Gymnasium): One part of the sample (N = 10) consists of 7th grade classes, while the other part (N = 15) consists of 10th grade classes. The video data concentrate on lessons on the topics "state of matter" and "acids, bases, neutralisation". The following diagrams have been designed to evaluate the communication processes in science lessons and, most importantly, to answer how teachers deal with students' statements and misconceptions. Communication patterns in which teachers effectively prompt or ask for reasoned students' statements are important for encouraging students to express their ideas more qualitatively and proactively. Additionally, these patterns are assumed to be a prerequisite for learning about students' misconceptions. The following figure (figure 2) provides observers with a brief overview of a diagrammed lesson:

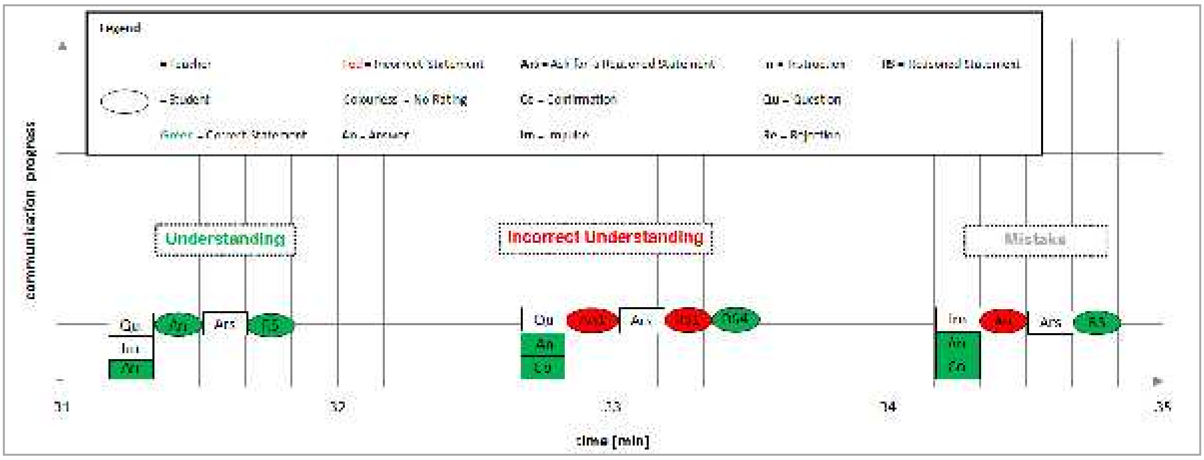

Figure 2. Prototypical Elements of Communication Process Diagrams

The whole communication process diagrams (see Figure 2 for prototypical elements) are developed in a two-dimensional coordinate system with time on the x-axis and communication progress on the y-axis. The prerequisite for using communication process diagrams in the analysis of student-student or teacher-student discussions is a clear definition of the symbols (see shortcuts in the legend). First, there is a distinction between a rectangular symbol for the teacher and the ellipse for the student. The statement of the student or teacher is followed by a specification of the statement: answer (An), ask for reasoned statement (Ars), confirmation (Co), impulse (Im), instruction (In), question (Qu), rejection (Re), and reasoned statement (Rs). The third color-based criterion (green/red) divides between student/teachers' statements which are correct or incorrect from a scientific point of view. With every new scientific statement, the communication progress enters a new level in the diagram. The communication process diagrams show typical communication patterns in a chemistry classroom. In a first step, 25 videos of grammar school chemistry teachers were analysed with the help of communication process diagrams.

RESULTS

The following communication process diagrams represent two examples of communication patterns found in chemistry classes (see Figure 3):

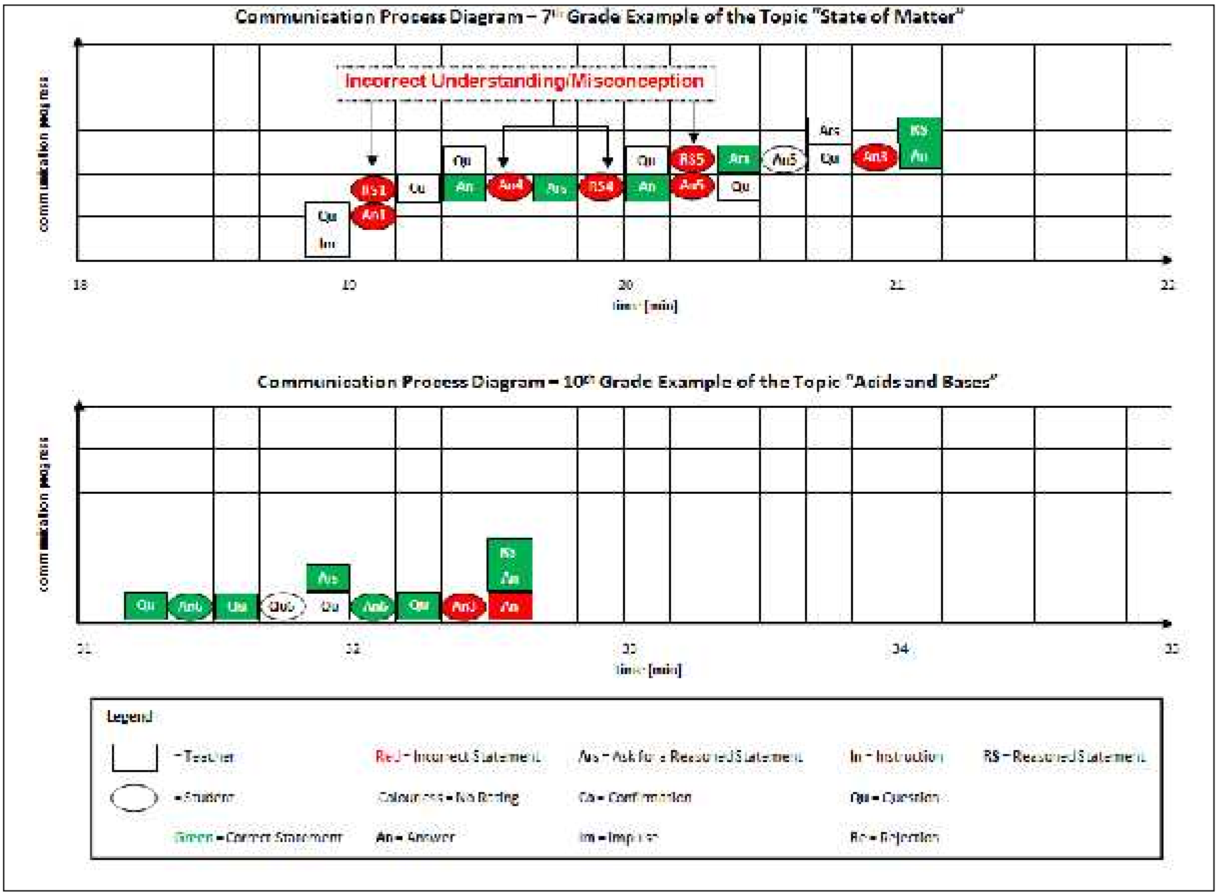

Figure 3. Communication Process Diagram/Example 7th Grade/10th Grade

In order to give a short example for one type of communication process (7th grade) we focus on the communication patterns from minute 18:50 to 20:20. The communication process starts with an impulse and a question of the teacher combined in one statement. Then student no. 1 gives an incorrect answer and a wrong justification. In this moment, the teacher might recognise and act on the incorrect reasoned statement to test if the student has an understanding which is incorrect from a scientific point of view (pointing at a misconception). Instead he continues the lesson with a confirming statement, the correct answer, and the next question. As student no. 4 gives a short incorrect answer, the teacher asks for explanation. The wrong justification follows and the teacher gives the correct answer and poses the next question. Then, a long statement with an answer and explanation, which are wrong from a scientific point of view, is given by student no. 5. This illustrates an incorrect understanding and indicates a new misconception.

The second communication process diagram shows a communication-sequence of two minutes in a 10th grade lesson on the topic “acids and bases”. In minute 31:00 to 32:30, it is shown that the teacher dominates the communication by his way of narrow questioning. The teacher asks a short question which is correct from a scientific point of view. Student no. 6 gives a short correct answer, the question from the teacher follows and the next question from the student no. 6 is articulated. The teacher continues the lesson by giving an impulse and asking a question in one statement. As a consequence, the student gives the next short answer, the teacher poses the next question and the incorrect answer from the student no. 3 follows. There is no opportunity to identify students’ misconceptions as the teacher does not ask them to justify their statements. A student-student or teacher-student discussion is important to learn about students’ ideas. That is a fundamental prerequisite to understanding and dealing with students’ misconceptions.

DISCUSSION AND CONCLUSION

The analysis of communication patterns predominantly shows that the course of the lesson is decisively determined by teachers’ behaviour: Lessons are teacher-oriented and dominated by their activities. Verbal communication, even among students, is also controlled by the teacher. Primarily in 10th grade classes, teachers asked narrow, leading questions by putting the answer in their students’ heads instead of leaving their questions open-ended. The teachers did not seem to take students’ statements seriously. Providing instruction that takes students’ misconceptions into account was barely possible, because extensive student-student and student-teacher discussions were not fostered. Reasoned student statements that would have highlighted any misconceptions were not supported.

In contrast, the teacher in the 7th grade example asked questions fostering students’ reasoning and he seemed to be more competent in identifying students’ misconceptions. One reason for this is that asking for explanation enhances the quality of learning and higher order questions challenge the learners to interpret, analyse, and manipulate information in ways that are not simply routine applications of previously acquired knowledge (Chi et al., 1994; Newmann, 1988).

The presented communication process diagrams can be a helpful observation tool for analysing classroom activities. One strong point of these diagrams is that they clearly illustrate the progression of the lesson and especially how teachers deal with their students’ statements and misconceptions.

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ACTING WITH PENDULUM

THE PROCESS MATTERS WHERE THE OBJECT ALSO SHOULD

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Abstract: This paper analyses factors affecting undergraduate Lao students' activities during their first laboratory work in physics - the pendulum experiment. Seven student groups (of three students each) were selected and video recorded at the National University of Laos. Each recording lasted on average about 55 minutes. In addition, the students' lab reports were analysed. The Cultural- Historical Activity Theory (CHAT) was used as a theoretical framework for the data analyses. The findings indicate that nearly all students had difficulties handling the equipment. Students conducted measurements but did not have clear understanding of the objectives of the experimental task. Their lab reports contained tables with data collected and mathematical calculations but had no discussion related to the physics of the experiment, accuracy of the measurements or reflections about the trustworthiness of the results obtained. The process of doing the experiment appeared to be more important than related learning outcomes. Using CHAT conceptual framework, it is possible to state that the *object* of practical activity was not perceived by the students. They were doing many practical *actions* without interconnecting them into meaningful laboratory *activity*. Lack of experience of doing practical work, gap between theory and practice, poor quality of the lab instructions, and faulty equipment were identified as other factors affecting the efficiency of the experiment.

Keywords: CHAT, pendulum experiment, student activity, undergraduate physics education

BACKGROUND

Practical work is broadly recognised as a necessary component of physics studies at school and university. It intends to help students develop their skills of using experimental equipment, enhance understanding of theories and make them familiar with the routines of scientific work (Lunetta, Hofstein and Clough, 2007).

The Cultural-Historical Activity Theory (CHAT) is used in this study as a theoretical framework to analyse students' pendulum experiments at the National University of Laos (NUOL). The *subject* of this activity is a learner/first year student. According to CHAT (Leont'ev, 1981), any *activity* is directed towards and defined by the *object* of the activity (in our case, laws of physics / phenomenon of periodic movement) and mediated by some *tools* (pendulum, measuring instruments, concepts and formulas). The laboratory activity is taking place in the socio-cultural context of NUOL that does not stimulate the implementation of practical work (Popov, Vilaythong, 2010).

The related learning activity is presented schematically in the fig. 1 below.

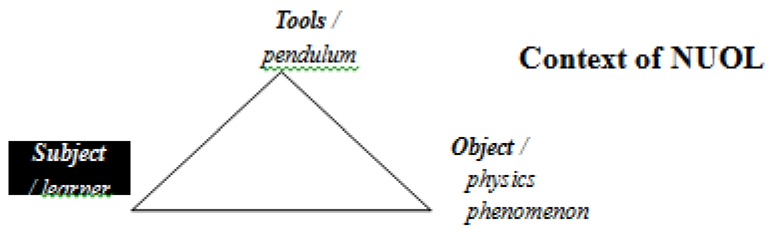

Fig. 1 Schematic representation of learning activity described by CHAT

According to Davydov (1996), any *activity* answers to specific needs of the subject (why to do?). It hierarchically consists of *actions* driven by perceived goals (what to do?) and *operations* that characterise a technical side of carrying out an action, which can be referred to as technique or skill (how to do?). Theoretically speaking, for the success of a learning activity it is important that the students have more-or-less clear answers to the questions posed in the parentheses, i.e. they have to be aware about *object of activity* and capable to carry out intended *actions* with related *operations*. It is then the expected learning outcomes can be achieved.

At NUOL, the introductory physics course for the first year students consists of three components; theory/lectures, problem solving exercises, and experiment sessions. The course is given in the second semester. Students come to experiment class every second week for 1,5 hours. Each class has six different experiment stations, pendulum is one of them. Students do experiments in group but write individual reports following a form given in the lab instruction.

A precarious situation with practical work in physics education in Laos at macro–level (national and institutional) was discussed by the authors earlier (Popov & Vilaythong, 2009). This paper analyses Lao student activities during laboratory work pendulum at micro-level (learner's activity) by focusing on the question: What factors influence student learning from the experiment?

METHODS

The data was collected during laboratory work sessions at the Department of Physics, NUOL in March-April 2008. Seven groups (of three students each) doing the pendulum experiment as the first of six planned laboratory sessions were included in the study. Thus, these students did not have previous experience of doing physics experiments at a university. They took part in an introductory physics course given to the students from the faculties of Forestry, Medicine, Environment, and Science. Many of these students had rather poor knowledge of physics from school and they did not have lectures on the theory of oscillations (pendulum) before the experimental session either.

At the beginning of each laboratory session, the group working on the pendulum experiment was asked permission to be recorded on video. The duration of recording for each group lasted about
55 minutes. Instructions related to laboratory work, video recordings, and student lab reports from the recorded students were analysed.

In the process of videotape analysis the tapes were played at least twice in order to get a clear picture of the students' understanding of the lab instructions, and the factors affecting the students' activities. The lab reports were carefully read with an intended focus of eliciting students' understanding of their tasks and the laboratory procedures reported. The theoretical lens of CHAT was used for interpreting findings.

RESULTS

From the analysis of the lab instruction it became clear that the students were provided information about what they expected to do during the experiment: observe oscillations, identify factors influencing the period of the pendulum, and finding out the value of the acceleration due to gravity, ***g*,** based on the formulas and a graph related to pendulum movement that they had to derive by themselves. Thus, students were given instruction about *what to do*, but not *why* or *how*. They were not informed from the previous theoretical sessions or the teacher / laboratory instructor about the role of the pendulum experiment in their physics course. Why was it important to do the experiment? What principles and laws of physics were they expected to learn from this laboratory work? So, the meaning of doing the pendulum lab activity (its *object*) remained beyond the learning or grasp of the students. The students were merely focusing on the process of conducting different *actions*.

In addition, the process of *how to do*: setting up the equipment, taking measurements and data analysis were not presented clearly enough in the lab instructions either. So, students seemed rather confused in the videotapes when they collected data. They showed difficulty in understanding how to read values of pendulum period on the mechanical stopwatch scale (where one round of the big pointer counts to 30 seconds). They spent a lot of time setting the protractor to measure angles (the equilibrium position of the pendulum was located at 90 degrees on the protractor scale and the angles to be measured as deviations from this position) and resetting the length of the pendulum to exact values as given in the lab instruction. These apparently simple *operations* for university level students that could easily be automatised by now appeared to become rather complex *actions* for the Lao students.

Most of the groups also made a lot of errors during measurements and calculations. The analysis of lab reports showed that the students calculated the value of ***g*** using formulas from the literature and collected data, but the majority got values of ***g*** far from 9,8m/s^2 and did not notice or reflect
in the report about this. Reports contained tables with data and mathematical calculations but no discussions of the physics of the experiment, accuracy of the measurements or reflections about the trustworthiness of the results obtained.

Additional factors affecting the student's activities during pendulum experiment appeared to be related to the quality of *mediating tools* such as lack of students' experimental skills and general knowledge of physics, faulty equipment, and poor quality of the laboratory instructions. These factors mirror the problems in the broader physics education context of Laos where laboratory activities are located (Popov & Vilaythong, 2009).

CONCLUSIONS

The study revealed that the focus of laboratory work was on the processes of manipulating equipment and doing calculations. Students were all the time busy with these two procedures. Apparently the *object* of practical activity was not clearly defined in the lab instruction or by the teachers. Therefore expected learning outcomes of the activity were not clear for the students either. Students conducted measurements but they did not show clear understanding of the objectives of the experimental task and the physics they were expected to learn. The results obtained are in tune with the study of Abrahams and Millar (2008) who found that practical work was effective in getting students to work with equipment but much less effective in getting them to use scientific ideas to guide their actions and reflect upon the data they collect.

CHAT perspective regards the *content* of human activity as determined first of all by its *object* (Leont'ev, 1981). It is therefore possible to state that perceptions of teachers and students of the *object of activity* define how the learning activity is organised and how the learning motives, actions, and strategies of students are shaped. In case of the laboratory activities at NUOL, the *object* of the experiment was not clearly defined and presented by the lab instructions or the teachers. Therefore, students' laboratory activities became rather eclectic collections of different *actions* lacking unifying ideas about gaining adequate knowledge of physics that increased their understanding of certain physical phenomena.

Another factor affecting quality of the pendulum experiment was poor *mediation* of activity characterised by lack of the experimental skills of the students, faulty equipment and lack of some important information in the lab instructions. Theyßen (2007) suggested that for traditional lab work course the theory background for each topic has to be acquired in advance before the experimental phase and all necessary information and advices concerning the experimental tasks should be included in the lab guide. At NUOL students often do the experiments before they get lectures on the corresponding theory, so they do not have necessary theoretical *tools* for grasping the *object* of their learning activity or lab work. Without holistic understanding of the *object of activity*, laboratory work will remain for the students a set of compartmentalised *actions*.

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COMMENTS ON THE RESULTS OF A TEACHING INTERVENTION ON EVOLUTION. WHICH PUPILS BENEFITED?

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Abstract: In the present research the endeavour to teach the theory of evolution by natural selection, which took place in an average state school in Greece, is described. The instruction included efforts to make pupils express their conceptions, to confront them and replace them with more accurate ones. To make this happen the instructional design integrated the pupils' high engagement through discussion and juxtaposition of their conceptions. The purpose of the research was to ascertain a) how were pupils' conceptions formed after the instruction and b) which were the probable reasons that influenced the results of this endeavor.
As the research showed the teaching intervention resulted in more pupils accepting biological evolution and evolution of humankind, the reliability of the theory of evolution and the randomness in the production of the variation. As far as natural selection is concerned, the teaching intervention helped nearly half of the pupils to learn to use it with consistency. Pupils with richer conceptual background were able to see systematically how their prior conceptions contradicted the scientific theory they were taught.

Keywords: Evolution, natural selection, lower secondary school, teaching intervention

BACKGROUND, FRAMEWORK, AND PURPOSE

Natural selection is in the center of the Darwinian theory of evolution. Other procedures have played an important role in the history of life, but no other force except for selection can explain the complexity of life, the intricacy of the survival mechanisms of various organisms and their adaptation to their environment (Futuyma, 1986). Natural selection "is a core concept of the secondary school biology curricula" (Brumby, 1984, p.499) and without a working knowledge of it, it is impossible to understand the diversity and complexity of life (Gregory, 2008).

Nevertheless, a great number of science education research papers (at least in the English bibliography) have shown that many pupils have a plethora of alternative conceptions on the theory of evolution including Lamarckian misconceptions (Enderle et al., 2009; Lucas, 1971; Brumby, 1979, 1984; Bishop & Anderson, 1990; Greene, 1990; Jiménez-Aleixandre, 1996; Samarapungavan & Wiers, 1997; Jensen et al., 2007). A documented presentation of world-wide studies on this issue is presented in Gregory (2008).

A research conducted in a large sample of pupils from many different schools in our country (Prinou et al., 2008) had shown that secondary school pupils appeared to be favorably disposed towards biological evolution. However, despite the fact that the theory of evolution by natural selection was included in the 9th grade biology curriculum, pupils' explanations were teleological (goal-directed). Pupils did not use natural selection to explain evolutionary changes, but treated organisms as a unified total of almost identical individuals, which acquire new traits in order to deal with the needs of the environment. Following that, organisms passed on the new traits to their offspring.

Also, another research conducted in our country (Prinou et al., 2011) indicated that the intuitive teleological reasoning of primary schools pupils (Kelemen, 1999; Bloom & Weisberg, 2007) is not questioned or destabilized during primary education and thus it is

carried on to the next levels of education and it also influences the teaching of biological subjects in higher grades.
According to Sinatra et al. (2008, pp.193-194) learning about a complex process like evolution, requires conceptual change. The educators who foster conceptual change must be aware of students' preconceived ideas that they bring to the classroom, and must design instruction to give them the opportunity to think deeply about alternative perspectives. According to Sinatra et al. (2008, pp.193-194) the likelihood of change relates to the degree of pupils' engagement, that is how deeply students become involved in the content through discussion, debate or dialogue.
Taking into account the result of all the above-mentioned studies we attempted the introduction of the teaching of the theory of evolution by natural selection fostering conceptual change. The instruction took place in an average state school in Greece in the context of the existing 9th grade biology curriculum (as a last unit as it is placed in the curriculum)[1]. The purpose of the research was to ascertain: a) how were pupils' conceptions formed after the instruction and b) which were the probable reasons that influenced the results of this endeavor.

METHODS

- First as *a pre-test* the *Questionnaire1* (Q_1) was given to pupils, that was intended to make pupils express their views and conceptions on this subject. This consisted of open-ended and multiple choice questions. The multiple choice questions were four-grade scale statements (Agree or Disagree absolutely or probably and don't know- no reply). In the open-ended questions pupils were called to explain instances of biological adaptation. The questions excited pupils' interest and this facilitated the conduct of the teaching intervention afterwards.
- The *Teaching intervention*

The subject content: It included basically the following issues: The variety of life and the similarities between living things, the evidence for evolution, Charles Darwin, Natural Selection, The origin of humans.
The *Instructional process that was adopted* (based on the model of conceptual change presented in Sinatra et al., 2008) included the continuous active pupils' involvement in this procedure, which took place with issues and questions that were posed for discussion in the class. The argumentative discussion for (or against) the validity of their explanations on subjects concerning e.g. biological adaptation of a large array of different organisms was used with pupils. Evans et al. (2010) refer that curricula which provide opportunities for generalizing across diverse species are more likely to be successful in relaying evolution.
Very special attention was given to the "language" that was used during the instruction, to make pupils "aware of the conflict" (Sinatra et al., 2008) between the manner concepts (e.g. adaptation, evolution) which are used in everyday language and scientific terminology. The exact content of the concepts and the difference between their meaning in everyday language and the theory of evolution was made totally clear.
The duration of the intervention was eight hours.

- As *a post-test* the Questionnaire 2 (Q_2) was given to pupils. That consisted of open-ended (with other scenarios) and multiple choice questions. The Q_2 was given a month after the Q_1.

The S.P.S.S. statistical program and content analysis were used to process both the questionnaires' replies.
As *a re-test* two optional open-ended questions that were set among others, in the final biology examination (one month later) taken by the pupils, were used. Pupils, who wanted to answer them, did so.

- Regarding the synthesis of the questionnaires and of the teaching material used in the intervention the above-mentioned relevant bibliography on evolution and the site Understanding Evolution[2] were taken into account.

The Participants pupils : 98 pupils of 9th grade, divided in four classes alphabetically. 62.2% were girls and 37.8% were boys. 98 pupils answered Q_1 and 95 pupils answered Q_2. Their general records in biology in a scale 0-20 were: a. the 25.5% had from 17 to 20 (or A), b. the 31.6% had marks from 13 to 16 (or B) and c. The 42.9% of pupils had marks from 9 to 12 (or C).

RESULTS

On the origin of species

The percentage of **76.8%** of pupils who accepted *that the species living today are the result of evolutionary processes that have been occurring for millions of years* when answering the Questionnaire1 (Q_1) increased to **85.3%** when they answered the Questionnaire 2 (Q_2), while the percentages of the other answers decreased.

N=95	Agree %	Disagree %	Don't know- reply %
Q_1	**76.8**	13.7	9.5
Q_2	**85.3**	7.4	7.3

The correlation between pupils' answers in Q_1 and Q_2 on the origin of species proved to be statistically significant with χ^2= 10.733, BE=4 and p-value=0.030<0.05.

On the origin of humankind

The percentage of **59%** of pupils who accepted that *humankind has evolved from earlier forms of life* when answering Q_1, increased to **82.1%** when they answered the Q_2, while the percentages of the other answers decreased.

N=95	Agree %	Disagree %	Don't know- reply %
Q_1	**59**	21	20
Q_2	**82.1**	10.5	7.4

The correlation between pupils' answers in Q_1 and Q_2 on the origin of humankind proved to be statistically significant with χ^2= 22.839, BE=4 and p-value=0.000<0.05.

On the evidence for evolution

The percentage of **35.8%** of pupils *who accepted that the available evidence are sufficient for the theory of evolution to be regarded as reliable* when answering Q_1 increased to **62.1%**, when they answered the Q_2, while the percentages of the other answers decreased.

N=95	Agree %	Disagree %	Don't know- reply %
Q_1	**35.8**	33.7	30.5
Q_2	**62.1**	15.8	22.1

The correlation between pupils' answers in Q_1 and Q_2 on whether the available evidence are sufficient for the theory of evolution to be regarded as reliable proved to be statistically significant with χ^2=19.158, BE=4 and p-value=0.001<0.05.

On the origin of new traits

The percentage of **15.8%** of pupils who accepted *that new traits originate randomly* when answering Q_1 increased to **58.9%** when they answered the Q_2, while the percentages of the other answers decreased.

N=95	Agree %	Disagree %	Don't know- reply %
Q_1	**15.8**	74.8	9.4

Q_2	**58.9**	33.7	7.4

The correlation between pupils' answers in Q_1 and Q_2 on the origin of new traits proved to be statistically significant with $\chi^2 = 12.447$, BE=4 and p-value=0.014<0.05.

On natural selection

Before the intervention the great majority of pupils' answers in the open-ended questions of Q_1 (n=98) did not use scientifically accepted explanations.

E.g. in the question which asked pupils to explain the insects resistance to insecticides[3] the majority of them (75.8%) thought that all organisms (taken as a unified whole of almost identical individuals) "have been transformed", in order to survive or that insects "became accustomed", "acquired immunity, antibodies"etc.

In another question, pupils were asked to explain how a species of wingless insects (feature that helps them not to be carried away by the winds into the sea) came to live on an island subjected continually to strong winds": 65.3% of pupils had answered that "the insects evolved in order to adapt …""their bodies were formed in accordance with the requirements for survival in their environment" or "their wings atrophied because they stopped using them".

The common points between pupils' answers were that the various features were acquired by all organisms (together) in response to environmental pressures. Then their offspring inherited the new traits. Pupils' reasoning was teleological.

After the intervention a number of pupils gave scientifically accepted answers. These answers included the following rudiments:

"In the past … a long time ago…there were some organisms which had the (specific) feature and there were some other organisms which they did not have it. These organisms that had the (specific) feature had an advantage over the others because ….These survived and had children (descendants) which inherited the (specific) feature. These children had an advantage over the others who had not inherited the (specific) feature. The ones who had the (specific) feature survived, while the other died. Gradually …with the passage of time, the percentage of the organisms with the advantageous trait increased… or …now the population consists of organisms with this specific trait…"

Analytically: in the open-ended question of Q_2 (n=95), which was referred to the explanation for the resistance of microorganisms to antibiotics[2], it was found that a percentage of pupils (62.2%) used natural selection.

- In the open-ended question which asked pupils to explain the existence of adaptive traits to dry environments of camels, a percentage of pupils (64.3%) gave a scientifically accepted explanation.
- In the open-ended question which asked pupils to explain another instance of evolutionary change (the cheetahs' ability to run faster than their ancestors[4]) a percentage of pupils (51%) used natural selection.

However, a percentage of pupils continued to answer the questions with misconceptions. The common points between pupils' answers were that the various features of organisms were acquired by all organisms (together) in response to environmental pressures. Then their offspring inherited the new traits. Although pupils' answers had small variations, they described biological adaptation by the use of verbs "organisms mutated, adapted in order to survive, changed little by little from one generation to the next in order to" etc. Their reasoning was still teleological.

N=95	Natural selection	Answers with common misconceptions	No reply/ Tautological
1.Resistance of microbes in	62.2%	29.6%	8.2%

antibiotics			
2.Camels'adaptive traits to drought	64.3%	25.5%	10.2%
3.Cheetahs' ability to run faster	51%	30.6%	18.4%

- The correlations between pupils' answers to each question and their marks in biology proved to be statistically significant. Analytically:

- The correlation of pupils' replies to the first open question and their marks in biology proved to be statistically significant with $\chi2= 32.543$, BE=6 and p-value=0.000<0.05 and showed that the majority of pupils who used natural selection to answer the first open question had high marks in biology i.e. A (the 39.3%) and B (the 32.8%). Also the majority of pupils (the 95.6%) who answered that insects (altogether) "changed" (adapted) in order to survive had average (the 47.8% had B) and low marks (the 47.8% had C) in biology. All the pupils (100%) who answered that they do not know or they gave tautological answers had low marks in biology.
- The correlation of pupils' replies to the second open question and their marks in biology proved to be statistically significant with $\chi2= 18.879$, BE=4 and p-value=0.001<0.05 and showed that the majority of pupils who used natural selection to answer the second open question had high marks in biology i.e. A (the 38.1%) and B (the 31.7%). Also the majority of pupils (96%) who answered that the camels adapted in order to survive had average (the 36% had B) and low marks (the 60% had C) in biology. The majority of pupils (the 80%) who answered that they do not know or they gave tautological answers had low marks in biology.
- The correlation of pupils' replies to the third open question and their marks in biology proved to be statistically significant with $\chi2= 22.610$, BE=4 and p-value=0.000<0.05 and showed that the majority of pupils who used natural selection to answer the third open question had high marks in biology i.e. A (the 42%) and B (the 34%). Also the majority of pupils (90%) who answered that the cheetahs adapted in order to survive had average (the 36.7% had B) and low marks (the 53.3% had C) in biology. The majority of pupils (the 77.8%) who answered that they do not know or they gave tautological answers had low marks in biology.

- The correlations of pupils' replies to the second open question and their conception on the origin of the new traits proved to be statistically significant. Analytically:

The correlation of pupils' replies to the second open question and their conception on the origin of the new traits, proved to be statistically significant with $\chi2=10.826$, BE=2 and p-value=0.004<0.05 and showed that the majority of pupils (70.5%) who used natural selection to answer the second open question accepted that new traits originate randomly.

The correlation of pupils' replies to the third open question and their conception on the origin of the new traits, proved to be statistically significant with $\chi2=6.916$, BE=2 and p-value=0.031<0.05 and showed that the majority of pupils (75%) who used natural selection to answer the third open question accepted that new traits originate randomly.

- **Natural selection as an explanation in all three open-ended questions**

- 43.8% used natural selection in all three open-ended questions.
- Half of these pupils (46.5%) had high grades in biology (A). 80% of them were girls.
- One third of the pupils (30.2) who used natural selection to all questions had μέτριους marks (B). 70% of them were girls.
- The rest of the pupils (23.3%) had low marks. 80% of them were girls.

- **In the re-test** two open questions on (different) instances of biological adaptation, that were given among others in the final biology examinations (one month later) taken by the pupils, were used.

- 92 pupils chose to answer the first open question referring to the evolution of the beaks of birds living on an island with plants producing small seeds. 70.7% of them used natural selection.
- 82 pupils chose to answer the second open question. Pupils were asked to explain the existence of adaptive characteristics of seals. 54.9 % of them used natural selection.
- 53.6 % of pupils who chose to answer both questions (n =82) used natural selection to each one of them.

DISCUSSION AND CONCLUSIONS

The teaching intervention resulted in more pupils accepting biological evolution and evolution of humankind.
The percentage of pupils who accepted the reliability of the theory of evolution was increased. However there were a percentage of pupils which did not answer or accept this statement. A great increase of the percentage of pupils who accepted the randomness in the production of the variation, which is a prerequisite for the "action" of natural selection, was ascertained. Nevertheless there were a remarkable percentage of pupils which had difficulties in accepting the role of chance in the origin of new traits of organisms. As it was shown in pupils' answers and their correlations, the recognition of the role of chance in the origin of variation perhaps leads to the conception of natural selection more easily.
After the intervention, a number of pupils were able to use natural selection in each question, while a smaller percentage used natural selection with consistency, i.e. they used it to answer all open-ended questions.
The great majority of pupils who appeared to be able to use natural selection to answer all questions were pupils with good and average marks in biology, result that could be explained in different ways. A probable explanation is that natural selection is a complex concept and its understanding presupposes the knowledge and understanding of other biological concepts. Probably these pupils had a richer conceptual background that enabled them to see systematically how their prior conceptions contradicted the scientific theory they were taught. The other pupils probably having fragmented conceptual frameworks used natural selection in some questions and they tended to slip into their intuitive teleological conceptions in other questions.
Additionally, a percentage of pupils did not use natural selection but they repeated teleological explanations. Unfortunately these types of explanations had not been doubted during the previous years of pupils' formal or informal education. On the one hand, pupils had been taught the "adaptation of organisms" during the formal education problematically (Prinou et al., 2011). On the other hand, pupils have watched documentaries on television programs etc., where the "adaptation of organisms" is presented problematically also.
Probably there are also other reasons responsible for the fact that pupils were not able to use natural selection. These reasons should be taken into account when designing a new teaching rubric fostering conceptual change for all pupils ; maybe the time devoted to the instruction was limited; or the time when the instruction took place (end of the school year as it was scheduled in the curriculum) ; or perhaps that the intervention did not interest all pupils. M. Evans (2008) has commented that the persistence of misconceptions is probably due to the fact that students who are taught biology are not (always) interested in acquiring a deep understanding to comprehend evolutionary concepts but merely in passing the course.
In the next phase of this research we are going to collect more data through pupils' interviews and recording of their discussions on the previous issues. Also we are going to record the development of pupils' conceptions as they evolve and follow the next school grades.

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NOTES

[1]Our intervention differed from other studies published in the bibliography in that it was shorter in length and the whole biology curriculum was not reorganized. The other studies published in the bibliography are not presented in this paper because of the lack of space for which we apologize.

[2]Understanding Evolution: University of California Museum of Palaeontology. http://evolution.berkeley.edu/evosite/evohome.html.

[3] Similar questions were first found in Brumby' research (1979, 1984) but they are also referred in contemporary textbooks

[4] Adopted by Bishop &Anderson (1990)

HOW TO HELP PUPILS TO BUILD UP SCIENTIFIC PROBLEMS IN BIOLOGY LESSONS

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Abstract: Our research aims at highlighting the conditions that allow the pupils to build up scientific problems during sessions including moments of debate in biology lessons. Our project is in line with the researches conducted in biology didactics on the role of linguistic interactions in scientific learning. In this study, we try to clear up the strategies used by teachers to change pupils' understanding of biological phenomena and encourage their involvement in the building up of a scientific problem. Our research data were collected in a 6th grade class and in a 10th grade class. Through examples observed in these classes, we have examined the way teachers manage a discussion about pupils' different attempts at explanations and how they lead them to change their points of view. In this contribution, two biological topics are concerned: the recycling of theorganic matter in ecosystems (6th grade class); the supply of dioxygen in the body (10th grade class).

Keywords: linguistic interactions, problem building, enunciative posture, professional gesture, inducer of problematization

1. INTRODUCTION

Our research aims at highlighting the conditions that allow the pupils to build up biological problems during sessions including moments of debate in the classroom.

We try to clear up the strategies used by teachers to change pupils' understanding of a biological phenomenon and encourage their involvement in the building up of a scientific problem.

In our analysis of the teacher's activity, we have tested Fabre's and Musquer's hypothesis (2009a, 2009b), especially their idea of "*inducer of problematization*" In spite of the wide variety of inducers of problematization implemented by the teachers, we found similarities between the two analysed sequences. In this paper, we study some of those similarities. This study allows a better understanding of the process of problematization.

2. RATIONALE AND PURPOSE

In French secondary school, science teachers are encouraged (by recommendations from their hierarchy) to organize their teaching around a scientific problem but most often they present the problem to the class and the pupils have to try to solve it. In this case, the question of the construction of the problem is avoided and its role is often underestimated

A specificity of our approach is related to the articulation between the theoretical framework of problem building - elaborated by Fabre and Orange (1997), CREN laboratory, university of Nantes - and a socio-historical approach of learning, which considers that school must allow pupils to rebuild knowledge available in culture and the ways of thinking, speaking and acting associated with this knowledge (LACES laboratory, University of Bordeaux: Ponce & Schneeberger, 2002 ; Lhoste, 2008; Rebière, Schneeberger & Jaubert, 2009; Schneeberger &

Vérin, 2009). More precisely, we assign a decisive role to the pupils' problem building in the construction of biological knowledge.

The teacher's role is complex because he or she must encourage pupils to move from a position rooted in everyday life to a scientific approach. At the same time he or she must ensure a psychological continuity and he or she must also impulse an epistemological rupture between the first questions and the biological problem. Many studies conducted by researchers in biology didactics try to understand how the teacher manages to introduce a scientific problem to the class and to what extent it is possible to associate the pupils in the process of problem building in biology.

With reference to a rationalist approach, we argue that the main goal of science-teaching is to enable pupils to abandon common-sense reasoning and to develop a scientific approach of the understanding of biological phenomena. Such an improvement is possible only if teachers set up adequate teaching situations, which implies obeying specific conditions which characterize the scientific activity. We propose to investigate these conditions, particularly those that promote the pupils' involvement in a scientific problem building.

3. THEORETICAL BACKGROUND

During our research, we used the concept of "inducer of problematisation", developed by Fabre and Musquer (2009a, 2009b). These authors assume that various kinds of "inducers" can act to stimulate specifically different cognitive operations involved in a process of problematization.

Figure 1 is a model of the process of problematisation according to Fabre (2009) completed with inducer of problematisation (Fabre & Musquer, 2009a, 2009b)

Various kinds of "inducers" can act to stimulate specifically different cognitive operations involved in a process of problematisation.

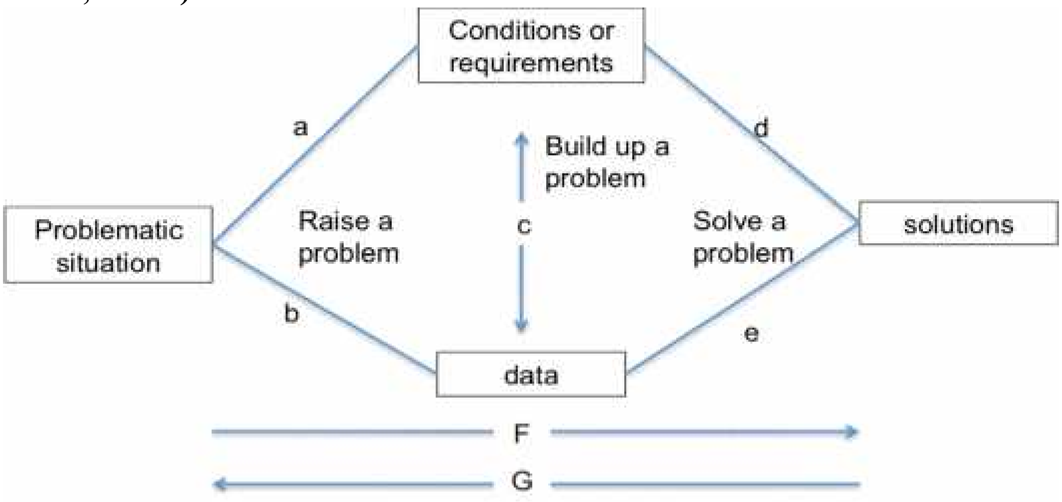
Macroinducers are directly connected to the situations and to the tasks proposed by the teaching devices :

- F: inducer F leads to building potential solutions
- G: inducer G leads to consider solutions, whether possible or not, in a critical way, by reconsidering the problem

Other inducers, less obvious, are linked to the teacher's oral interventions during the debate :

- inducers helping to pose the problem, with more or less specification of the conditions (type a) or the data (type b)
- inducers aiming at the expression of hypotheses or critical analyses of solutions according to the conditions (type d) or the data (type e)
- inducers aiming at connecting the conditions and the data of the problem

Figure 1. Model of « inducer of problematisation » (according to Fabre & Musquer, 2009a, 2009b)



4. DATA & METHODS

Using examples observed in classes of different levels on various biological topics we have examined the way teachers manage debate from different pupils' attempts at explanation and how they lead them to change their points of view (Schneeberger et al., 2007; Schneeberger & Lhoste, 2010). More precisely, we study how the teacher acts in order to make the pupils consider the problem as their own. For this purpose, we examine how the problem, as the teacher formulated it in his or her preparation papers, is introduced to the class, how the discussion before and after its formulation contributes to make pupils understand its meaning as a real problem. We search what conditions the pupils have to build up before understanding the meaning of the question and how the teacher acts to make it effective.

Our research data were collected in a class of 11-12-year-old pupils (6th grade) and in a class of 15-16-year-old pupils (10th grade) whose teachers are associated with the researches conducted by our teams. The data collection took place during sessions including moments of scientific debate in class.

The corpus includes various data
- the teachers' preparatory work;
- the transcripts of the video recordings of the session;
- the transcripts of the teachers' interviews (self-analysis)
- the pupils' written tasks

Two topics were studied during the sessions.
- The 6th grade pupils (11-12 years old) study the recycling of organic matter in ecosystems. This lesson aims at explaining the origin of mineral salts in the soil in order to enable the pupils to connect the presence of mineral matter in the soil with the decomposition of organic matter thanks to the action of the decomposers.
- The 10th grade pupils (15-16 years old) study the supply of dioxygen in the body during physical effort. This lesson entitled "The functioning of the human body" aims at initiating the pupils to the concept of integration of the functions of the human body, as the official French education curriculum specifies: "the contents of this chapter constitute a first approach of the concept of regulation".

4.1. Extracts from the French curriculum

Table 1. The content of the French curriculum

6th grade	10th grade
"Origin of the matter of living beings" (2008) This lesson aims at introducing the pupils to the recycling of the organic matter in ecosystems, so as to take it into account with the objective of sustainable development.	**"The functioning of the human body" (2001)** This lesson aims at introducing the pupils to the ***concept of integration*** of the functions of the human body. The contents of this chapter constitute a first approach of the concept of ***physiological regulation***. *The chosen topic is the study of the variations of the cardiovascular parameters in the human body during physical exertion.*

Our study is a qualitative study. The transcripts of the two sequences were analysed by focusing on what could characterize problem formulation in biology teaching.

Table 2. The two studied classes

6th grade class	10th grade class
11-12 years old, 13 students *10 cm of leaves gather on the soil every year, but after 100 years we don't walk on 10 m of leaves* **Explain what happens to the dead leaves.**	15-16 years old, 30 students *During a physical effort more oxygen is provided to the muscles whereas the oxygen rate in arterial blood remains the same.* **Explain how the muscles are supplied with dioxygen when the consumption increases.**

Our analyses mainly focus on one lesson in each class.

4.2. Methodology

Our methodology includes two steps :

1/ A "microscopic" analysis of every script :

- Identification of moments considered as important with regard to an epistemological point of view.
- Coding of previous interventions with an identification of the different inducers

2/ A comparison between different sequences about different topics observed in classes of different levels

5. RESULTS

5.1. A common characteristic

The analysis of the transcripts of the two sequences has allowed us to identify common points which could characterize problem formulation in biology teaching.

The analysis of the transcripts of the two sequences has allowed us to identify common points which could characterize problem formulation in biology teaching. Indeed, in both cases, the formulation of the paradox (where the problem is) does not appear immediately, contrary to what is implied in the examples of problem situations given by some authors (De Vecchi). Instead, it requires the construction of ideas without which the problem does not make sense for pupils.

6th example

In the sequence of the sixth grade class (recycling of organic matter in ecosystems), in order to formulate the paradox as such (20cm of leaves fall down every year, but after 100 years we don't walk on 20m of leaves), the pupils must have some idea of the conservation of the quantity of matter.

6th grade
After 100 years of deposits of 20 cm of leaves a year, the thickness of the ground has not increased while it should be 20 m thicker.
Condition to raise the problem : the idea of conservation is accepted by the pupils

Before formulating the problem to deal with, and just after having done it the teacher (Corinne) does not prompt pupils to enunciate this condition of the conservation of the quantity of matter straight away, but she leads them to reason in a way that includes this idea. This way, the pupils are enabled to understand the paradox as such (35-36). When the specific problem is formulated, the reasoning the teacher aims at encouraging implies that the idea of conservation is accepted by the pupils.

35	Teacher:	Yes / but once they're on the ground it's no longer living matter / all that can become dead organic matter in the end // the question is what what becomes of that dead organic matter /once it's there (put the « dead MO » label on the poster)
36	Pupil:	It decays
(…)		
42	Teacher:	Yes / we should walk on dead leaves 20m deep
43	Pupil:	Ah //
44	Teacher:	Dead leaves 20m high / that's nearly as high as that building / so when you go for a walk in the forest do you really walk on dead leaves 20m deep ?
45	Pupil:	Well no / xxxx / it's transformed/ xxxx
(…)		
107	Pupil:	Baptiste says it's because of animals / animals make it get smaller
(…)		
113	Pupil:	So Baptiste you said a while ago what animals do
114	Pupil:	They eat them
(…)		

131	Pupil:	But they'll decay anyway xxxx
(…)		
136	Teacher:	What sort of earth does it become //
137	Pupil:	Maybe some sort of a fertilizer
(…)		
150	Teacher:	Stop stop stop / I'll write that/to help plants grow / if your fertilizer helps plants to grow / what does it mean ? / What makes plants grow ? / You know that
151	Pupil:	It 's mineral matter
152	Teacher:	Here we are / Baptiste says it's mineral matter // good, but what are dead leaves ?
(…)		
170	Pupil:	Well / when they decay / they become // they become / as I said before / they become another / another matter / and that mixs with the air
171	Teacher:	Well / Gwénaël says when they decay / they become another matter // all right / so it 's not the same, is it?/ it turns into another / a another matter / because Hugo said a while ago / he said it scatters / Gwénaël says it gets very small // but does it disappear?
172	Pupil:	Well, no

It was only later, when she asked the pupils to look for solutions, that the teacher attempted to make the pupils clarify the idea of the conservation of the quantity of matter (171).

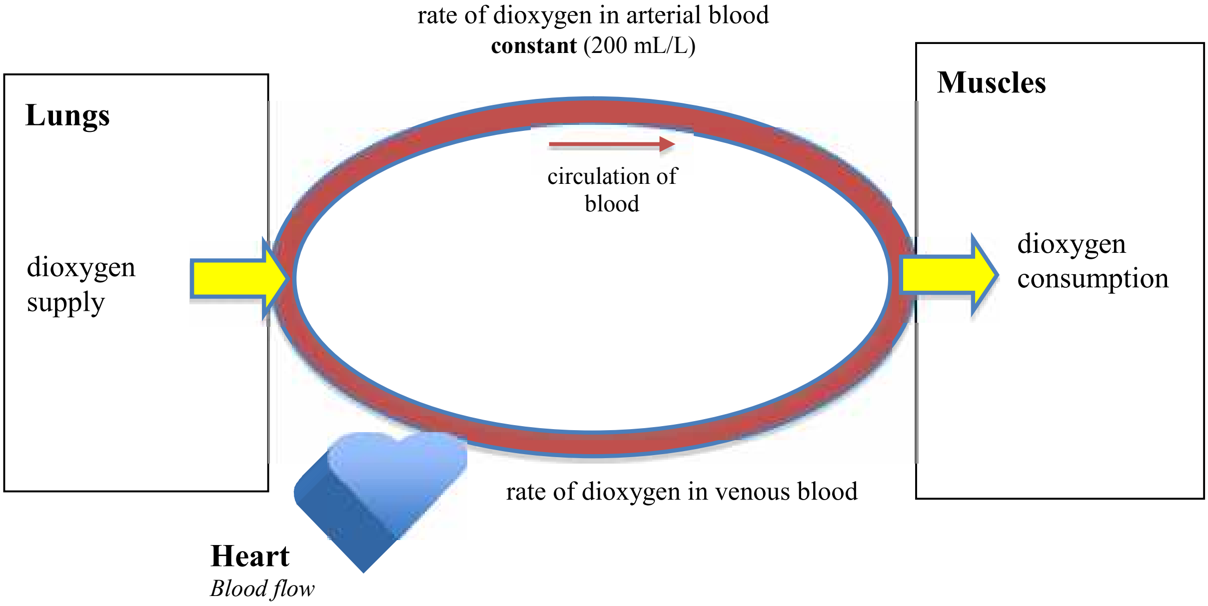
Thus the teacher helps the pupils to think in a way that implies this idea. Then the paradox becomes a paradox for them. Furthermore the teacher's interventions aimed at keywords such as "organic," "mineral," "dead matter" in order to initiate the idea of recycling. What is brought up is not directly the idea of the conservation of quantity of matter, but an idea of “becoming useful”, which anticipates the expected solution. The category “[organic] dead matter”, brought by the teacher led to the notion of a continuum between organic and inorganic matter in the foreshadowing of the cycle she wanted the pupils to build. Paradoxically, we can see that when the pupils tried to formulate the paradox using an example close to everyday life, their oral interventions involved an abstract model of the transfer of matter between plants, animals, soil, using scientific terms (mineral matter, organic matter), a model that they had been taught before. Thus, the notion of discontinuity which is the core of the scientific problem became a central idea in the discussion. The paradox was not formulated with scientific words (dead leaves, etc ...), but with arguments involving quantification, and the pupils attempted to match the two languages (dead leaves, dead organic matter).

10^th^ example

In the case of the other sequence (10th grade), in order to explain the paradox (*more dioxygen is provided to the muscles whereas the dioxygen rate in arterial blood remains the same during a physical effort),* some conditions are also required in order to be able to formulate the problem. The teacher managed to formulate the scientific problem (the paradox defined in section 1) when the pupils seemed to recognize it as such, because different conditions concerning the approaches of the relationships between data (including operating conditions) were identified by them. In the proposed situation, procedural operations are required because the relevant data to take into account in the biological problem studied (dioxygen consumption, dioxygen supply) are not direct data: in order to measure them, one must have the concentrations of dioxygen and use a multiplicative factor: dioxygen consumption = (rate of dioxygen in arterial blood – rate of dioxygen in venous blood) x blood flow.

10th grade
more dioxygen is provided to the muscles whereas the dioxygen rate in arterial blood remains the same during a physical effort
Condition : different conditions concerning the approaches of the relationships between data (dioxygen supply / dioxygen consumption)

Figure 2. The relationships between dioxygen consumption and dioxygen supply in the body



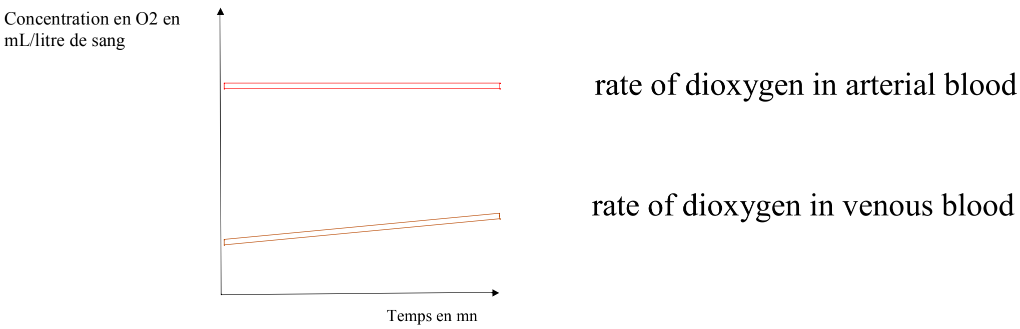
So, learning does not consist in a simple way: from the pupils' experience to more "scientific" formulations. Instead, to make the problem meaningful for pupils, links are required between experiences and models, with the purpose of building a scientific point of view.

5.2. Macro and micro-inducers

In the sixth grade sequence, we could say that, at a macro level, all the teacher's interventions represent a macro-inducer of position of the problem which occurs when she speaks of dead leaves in forests. That is what she wrote in her preparation paper, before the lesson. But before doing so, in each intervention (micro-inducers), she tried to make sure that the pupils build up the conditions so that the problem became a problem for them.

In the tenth grade sequence, the pupils must consider two curves at the same time (showing them the difference between the rate of dioxygen in arterial blood and the rate of dioxygen in venous blood) but they do not do it spontaneously. Usually, they first focused on a single curve. The micro inducers of the teacher this time aims at leading the pupils to take into account the two curves, and at focusing on their distance.

Figure 3. Production of one the group of students



Pupil:	I don't understand how there can be more dioxygen at the end than at the beginning
Teacher:	What matters is not each separate curve, but both considered at the same time / together it's the gap(s) / difference(s) between them/ The same blood ran through the muscles

So there seems to be a link between macro-inducers of the formulation of the problem with micro-inducers involved in the building up of the conditions which make this formulation possible. These conditions may also be conditions of solutions of the problem.

In both cases, the formulation of the paradox is possible thanks to an articulation between macroinducers and microinducers :

- Macroinducteurs G (in connection with the general organization of the sequence) in this case a criticism of pupils' answers

- Microinducers (a, b) (in connection with linguistic interactions).

6. CONCLUSION AND IMPLICATIONS

In this study, the methodology based on the comparison between two sequences using the model of inducers of problem building leads us to find similarities and differences.

The formulation of the problem is possible only if some necessary conditions have been constructed beforehand. So, not only the problem's solution has to be built, but also its formulation. Our "microscopic" analysis shows an articulation between these conditions and the identification of data to allow the pupils to build up the problem (theoretical data in the 6th grade, empirical data in the 10th grade).

We bring to light some differences.

In the 6th grade, the pupils' phrasing is not in accordance with scientific discursive community: they use scientific terms and everyday terms without making any difference between them.

In the 10th grade: pupils' phrasing is in accordance with scientific discursive community, but they have to improve their conceptual apprehension of experimental data.

Experienced teachers know that and do not start with giving the problem to be solved straight away, but first use macro-inducer of problem formulation articulated with micro-inducers so as to make the problem appropriatable by pupils. When training teachers, it could be useful to explain these articulations.

Our research has implication in two different fields:

Concerning research field, our results lead to a criticism of theorical models of problem building and inducers of problematisation.

Concerning teachers' training, our results lead to identify didactical skills teachers must develop in order to help pupils to build up scientific problems.

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GREEK TEACHERS' ATTITUDES, BELIEFS, KNOWLEDGE AND CONTEXT, CONCERNING EVOLUTION TEACHING

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Abstract: The aim of the present study is to record and assess several issues regarding teaching evolution in the Greek school since relatively little is known about the ways in which Greek secondary teachers understand the science of evolution and how they plan to approach most of the issues related to the teaching of evolution. In this study we performed ten one-on-one interviews, of approximately one-hour duration each. Interviewed teachers of several academic backgrounds were all teaching biology in secondary education. The recordings of the interviews were analyzed with the Qualitative Content Analysis (QCA) method and for the data mining the NVivo 8.0 software was used. Our findings indicate a shortage of proper teaching skills in the teaching of evolution among Greek-biology teachers, due to a lack in both, an acquaintance with general teaching strategies, in one hand, and a familiarity with the particular concepts related to evolution that they must transmit to their students. This is combined with the fact that some of them communicate the very same alternative ideas on evolution that one anticipates only from students to have. Finally, others encounter uneasiness to teach the particular subject due to their religious beliefs, a situation that is reflected on the effectiveness of their teaching, even when they try not to communicate this controversy to their students.

Keywords: evolution, biology, qualitative, greece, secondary- education, nvivo.

BACKGROUND & PURPOSE OF THE STUDY

Various scientific and other institutions consider evolution to be the central, unifying theme in biology and many science and science education associations have released position statements expressing their support for the teaching of evolution in science classrooms (Dobzhansky, 1973; National Academy of Sciences (NAS), 1998; National Association of Biology Teachers (NABT), 2002). Nevertheless, large percentages of science teachers reject evolutionary theory and support the teaching of antievolutionary ideas in schools (Nehm & Schonfeld, 2007). Thus, despite overwhelming agreement from the scientific and science education communities, evolution remains a problematic subject for many science teachers.

Numerous studies have explored contextual factors that complicate the effective teaching of evolution in schools. Teachers often do not want to teach evolution (Aguillard, 1999), do not feel adequately prepared to teach it (Aguillard, 1999; Griffith & Brem, 2004), and do not understand the legal precedents associated with evolution education (Moore, 2004). Many communities, school boards, and parents challenge teachers when they follow state and national standards and teach evolution (Chuang, 2003). These and other contextual factors are not surprisingly associated with teachers' emotional stress and negative perceptions regarding evolution (Brem, Ranney, & Schindel, 2003; Griffith & Brem, 2004). The teaching of evolution is a significant challenge for many science teachers. Finally, science teachers have conceptions about learning and teaching sciences, as a result of the many years they themselves have spent in school and university, accepting or rejecting the roles of their own science teachers (Hewson & Hewson, 1989).

The aim of the present study is to record and assess several issues regarding teaching evolution in the Greek school. More specifically, during the application of semi-structured interviews, we addressed the following research questions:

1. Which are the attitudes and beliefs of Greek teachers in regard to evolution teaching and how these affect their teaching practice?
2. How does the scientific and educational knowledge they have acquired during their studies or their professional development activities facilitate their teaching practice?
3. Do they find any particularities in the Greek school context that raise difficulties if they choose to teach evolution?
4. Is their religiousness engaged in any way to their teaching practice?

The open-ended structure of the interviews allowed the freedom of expression, which was anticipated to effectively capture answers in our research questions.

STATUS IN GREECE ABOUT EVOLUTION TEACHING

In the period we performed these interviews (spring of 2009), in the Greek educational system of secondary education (Gymnasium and Lyceum) there are three classes in each grade. But we teach Biology only in two classes, A and C for Gymnasium and B and C for Lyceum. C Gymnasium is the last class of compulsory education, and B plus C of Lyceum are two classes that basically prepare students for National Exams in order to enter the University. A chapter for Evolution is taught only in C Gymnasium, and the period we conducted the interviews there was not chapter about evolution in Lyceum.

Only the next school period, 2009-2010, a chapter for Evolution is part of the teaching material in C Lyceum, for all students, and was compulsory for the national exams (the situation is the same so far). Moreover, all science teachers (biologists, physicists, chemists, geologists, naturalists) can teach Biology in any grade (Gymnasium or Lyceum) in any class, although the headmasters always try to have a Biology teacher in their school at least for Biology in C class of Lyceum.

RATIONALE

While there is a growing body of literature about teachers’ attitudes and understanding of biological evolution in various international settings, relatively little is known about the ways in which Greek secondary teachers understand the science of evolution and how they plan to approach issues related to the teaching of evolution. Moreover, so far there are no data about educational context in Greece that might influence evolution teaching. Based on these results we focused on Pedagogical Content Knowledge (PCK), which will be examined in a further study. In this study, we focused especially on teachers because their role in evolution teaching is less studied, while there is only a minor report concerning teachers (Prinou, Halkia, & Skordoulis, 2005) and some other data concerning students (Kampourakis & Zogza, 2009).

METHODS

The research project is consisted of ten one-on-one interviews, of approximately one-hour duration each. Interviewing seems to be the most suitable method for this study because during discussion interviewers talk about several issues which cannot be pre-defined, as in a questionnaire. All interviews were semi-structured, having additional benefits: interview needs to leave room for the interviewer to ask clarifying questions. For credibility issues we made a member-checking analysis and also used a triangulation analysis in different levels, such as analysis from different researchers, using different analysis methods.

Interviewed teachers were from several scientific academic backgrounds: six biologists, two physicists, one geologist and one naturalist. All of them were teaching biology in secondary education, either in Gymnasium (13 to 15 years old students) or/and Lyceum (16 to 18 years old students). Their teaching experience ranged from 4 to 30 years.

All ten interviews were conducted and recorded. We ensured that the interviewees felt comfortable and were willing to discuss several issues. The recordings of the interviews were analyzed with the Qualitative Content Analysis (QCA) method (Mayring, 2000). For better analyzing and data mining the NVivo 8.0 software was used. We had to be familiar with NVivo8.0, so first we tried to learn the basic functions of this software and then to apply our analysis methods. Parallel to the use of NVivo8.0 we applied other analysis methods, as well, in order to ensure the accuracy of our results.

The data analysis procedure consisted of four steps: a) interviews were transcribed and analyzed, b) passages of the interview text related to the main research questions were chosen from the recording of the interview, c) different text passages concerning the same issue were categorized and integrated, d) categories within the different interviews that concern similar issues were brought together in order to get a picture of the main categories within this study.

During the analysis we reported codes (these are called “nodes” in NVivo), i.e. categories or subcategories for specific issues. For any of these codes we made several references which referred to words, phrases or even paragraphs with content relative to the specific code.

RESULTS

In brief, analyzing interviews and mining data from NVivo software, gave the following results:

- All ten interviewed biology-teachers think evolution as a central, unifying theme in biology and try more or less to teach it. They report evolution teaching as a problematic subject because of its reasoning and impact in several aspects of life. Even biology-major teachers, during their university studies learned about evolution at a high academic level, inappropriate for transforming scientific knowledge to school. It sounds peculiar, but some of biology-major teachers did not have any evolution course during their academic studies.
- Teachers report evolution teaching as a problematic subject because of its reasoning and impact in several aspects of life. Even biology-major teachers, during their university studies learned about evolution in a high academic level, inappropriate for transforming scientific knowledge to school knowledge. It sounds peculiar, but some of biology-major teachers did not have any evolution course during their academic studies.
- Teachers notice the importance of teaching evolution in primary schools and all of them understand the importance of evolution teaching. They feel inadequate to teach evolution and ask for more training on this specific subject or on how to teach the whole biology course. On the other hand, we can see that all of them focused on obvious misconceptions and did not take into account other more important parameters, such as teleological explanations, they do not really understand what evolution as “the unifying theory of biology” means and preferred to discuss evolution only within the context of the specific chapter. In some instances they were confusing the word “unifying” with the word “unified”.

Teacher:…well…ah…I think that according to up to now data we have, I think it is (the TE), a unified theory…I don't know what in the future will emerge…

- Some of the Biology teachers showed a total ignorance of the Nature of Science (NOS) in connection to the teaching of Evolution. At least one confused the term "theory" with an "idea".

  Teacher: …Telling your students about the theory of evolution is similar as telling them you choose…if you wish to call it a theory or an idea…it's up to you...

  This is probably related to the fact that during their studies they followed a curriculum totally directed towards Science in the typical context, without any enrichment with Epistemology, History and Didactics of Science. The historical view is absent in most of the interviewers' classes.
- Most teachers usually do not teach evolution, because of various weaknesses of the educational system: for example, evolution is the last unit in all textbooks, students' specialization in classes of Lyceum, there is ineffective cooperation between teachers and their mentors and lack of teacher training on this specific topic especially for non-biology majors, there is no any biology course in one out of three grades in Gymnasium and Lyceum, etc.
- They report lack of scientific and didactic knowledge in order to teach this specific topic of biology. This concerns both biologists and non-biologists teachers of biology. Moreover, most of the interviewers have no academic background about pedagogy and we reported some common misconceptions:

Teacher: ...natural selection involves organisms 'trying' to adapt", "natural selection gives organisms what they 'need...

All these result to inadequacy, decline self-confidence, stress, and trigger-off difficulties in teaching evolution.

- While all of the teachers in our study accept evolution to be either "a true theory" or a fact, most of them declared to be religious to various grades and shades. Some of them experience a controversy between their religious beliefs and their scientific understandings but they try not to communicate this controversy to their students. The type of the religiosity they have, does not discourage them from teaching evolution. While influences them in their personal thinking, at the same time helps them to address the subject in a different way from the one encountered in similar studies, let's say in USA, where students and teachers are taking Genesis in a literal way, even after evolution teaching (Nehm & Schonfeld, 2007). Nowhere in our study we encountered with teachers trying to persuade students for creation; basically we concluded that they would prefer not to talk about this issue (God, religion) in their classes, because they consider it as personal beliefs. For this reason they report that sometimes they feel embarrassed when they have to conflict with students' religiosity, but they really do teach science and report that none exogenous agent keeps them from teaching evolution.

Teacher: ... I try not to be wrong from the point of view of both theologians and biologists… that is to say. I do not give an answer that would be an error from the one or the other side…

Teacher: ... on the contrary I believe that we do not include by no means perfection because if existed perfection… they wouldn't exist [such monsters] that are created… if they were all so much perfect why so many types of species during the years were disappeared? … I believe that this is what the religion says. Something like that. I believe, I do not know… that all have come into existence in order to glorify the God…

Teacher: From a side I do not want to offend the religious believes the children have…that is to say… as an example… it had been said by some person that I suffer that I do not believe because at least those who they believe they believe that exists something else after the life…

Interviewer: As for Adam and Eve?
Teacher: That, I would answer, is part of the Hebrew mythology and they do not concern us today.

- They don't use the curriculum for their teaching, just the textbook. So their teaching is limited to the issues described in the textbooks and do not rely on targets, misunderstandings, teaching strategies, basic ideas and prerequisites which are defined in the Curriculum. So we noted differences in teaching progress, because the teachers have no common bases about what, how, and why they have to teach Biology and especially evolution. This problem becomes huge, if one takes into account that during their university studies, non-biologists did not take any biology course. Even biologists who had at least one course about evolution, they had it presented from a researchers' point of view and level with the result of being useless for their capacities as teachers of evolution in a school class. And if the absence of scientific knowledge about evolution seems as puzzle, the biggest problem is that no one of our interviewees had any course on the Didactics of Biology or any other course on Science Teaching. Only the neophytes of them during the first year of their teaching in school took part in a professional development course that included general teaching principles, but not Biology didactics, far more, any evolution teaching.
- It is important to mention that in one case when the teacher tried to reform the relationship between her students and the natural world using outdoor activities, including a museum visit, or giving the students the opportunity to see and touch fossils, the results were positive and students were more prone to evolution teaching, from there on. We think that it wasn't by chance that this specific teacher was a naturalist.
- Teachers of Biology in our study do not describe any social pressure against evolution teaching nor in schools neither in social settings.

CONCLUSIONS AND IMPLICATIONS

To sum up, our findings indicate a shortage of proper teaching skills in the teaching of evolution among Greek-biology teachers, due to a lack in both, an acquaintance with general teaching strategies, in one hand, and a familiarity with the particular concepts related to evolution that they must transmit to their students. This is combined with the fact that some of them communicate the very same alternative ideas on evolution that one anticipates only from students to have.

Others encounter uneasiness to teach the particular subject due to their religious beliefs, a situation that is reflected on the effectiveness of their teaching, even when they try not to communicate this controversy to their students. All these barriers underline the necessity to enhance the teaching of evolution theory in Greek Biology departments in a less "scholarly" way and improve in- service and future- teachers' training in pedagogical content knowledge in general and as concerning evolution teaching. Moreover, it is a necessity that there must exist training programs for teachers about evolution, so to make clear that evolution teaching is a unifying idea and can be taught throughout all biology units.

We see there are no exogenous factors that influence the way teachers teach evolution, or any complications due to religion beliefs. As far as religion is concerned, we conclude that this is an issue only for spiritual status of teachers, and does not affect the way they teach in general or evolution especially. The case seems to be different from cases like the one found by Nehm & Schonfeld (2007) for USA where they found that the increases in teacher knowledge about evolution and the nature of science did not translate into greater preference for teaching evolution in schools or greater acceptance of evolution, as it was depicted in their attitudes toward creationism. The latter, has been discussed by us in some other work and has being explained within the context of conceptual ecology that characterizes people from different social and religious backgrounds, affecting their attitudes towards evolution teaching and acceptance (Athanasiou & Papadopoulou, 2011).

We find several difficulties of school reality (such as apathy of the students, or missing hours for teaching, or inappropriate teaching material), but we are convinced that if teachers plan their lessons according to the curriculum and choose teaching strategies adapted to their classes, all these could be overwhelmed. All teachers have a positive attitude about evolution teaching, and this is an important base in training them adequately for evolution teaching.

Teachers should act as everyday researchers in their classroom, not only to teach but also to assess their teaching strategies, to take into account the class context, to evaluate their work and to cooperate with other colleagues in order to achieve the best result for their students. In this effort they need help from the state. The most appropriate and direct supporter, is the School Consultant and all of them, teachers, consultants, ministry officials of education should redefine the value and the role of consultants. We believe that they could offer a great job, because they are the intermediate between teaching practice of teachers and the state's strategy.

Finally, we should take into account not only the misconceptions about evolution teaching, but moreover the prerequisites that students should acquire in order to achieve long-term understanding of evolution teaching.

Our study project is continuing, in two directions: we focus on the PCK and investigate teachers PCK about evolution using questionnaires and organize a training program about evolution teaching using the Moodle e-learning platform. .

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DESIGNING VIRTUAL EXPERIMENTS IN ELECTRIC CIRCUITS BY HIGH SCHOOL STUDENTS

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Abstract: The purpose of this study is to evaluate the effect of investigative activities in virtual laboratory environments to the ability of students to design and perform experiments in the field of electric circuits. An inquiry-based teaching intervention with a degree of guidance from cookbook lab to challenge lab was applied to 14-15 years old high school students. A post-instructional assessment scheme with two extra tasks was used to evaluate the students' experiment design and execution skills. The students' skills were rated in ten dimensions and scored according to a 3-level ranking scheme. Results show that after instruction most students demonstrate a moderate ability in designing and performing simple experiments in the field of electric circuits.

Keywords: experiment design, electric circuits, virtual laboratory

BACKGROUND, FRAMEWORK, AND PURPOSE

Recent studies suggest that virtual laboratories (VL) provide affordances which can support students' engagement in experimental investigative activities and enhance their understanding of aspects of scientific inquiry (Klahr et.al 2007). Well designed guided-inquiry activities utilizing a virtual laboratory can involve students in scientific knowledge quest and may thus enhance their ability to design and perform scientific experiments. However, research has focused mainly on the effectiveness of VL to conceptual enhancement (Zacharia & Olympiou 2011); the potential of VL to foster the development of students' experimental design skills has not been adequately studied. Only recently have such studies been conducted in mechanics (Klahr et al. 2007) and thermal physics (Lefkos et al. 2011).

Our aim here is to extend this research to the field of electric circuits by studying whether the engagement of 14-15 year old high school students in a virtual laboratory (VL) environment carrying out a sequence of investigative activities can result in the development of their ability to design experiments in order to solve simple problems concerning electrical circuits.

RATIONALE

The ability to design experiments is considered to be one of the most important of the skills linked to laboratory investigations possibly surpassing in importance even the actual execution of the experiment as it is related not only to the content under study but to scientific methodology as well (Johnstone & Al-Shuaili 2001, Garratt & Tomlinson 2001). Virtual laboratory environments provide a powerful tool for investigative activities, since students can design aspects of an experiment using multimedia facilities, easily manipulate objects and try out investigations. Our approach draws on teaching science as inquiry utilizing an open virtual laboratory environment involving students in guided experimental activities. In designing experiments students are involved in identifying variables, listing the devices and instruments needed, describing the experimental setup, the phenomena taking place and the experimental process, taking and analyzing measurements, and evaluating results. Guidance is gradually fading away during the course of the activities and students are prompted to design the investigating experiments on their own.

METHOD

The teaching intervention took place in a junior high school in Greece in the field of electric circuits as part of the compulsory physics course. The sample consisted of 16 students of the 3rd grade of junior high school (Gymnasium), 14-15 years old. Instruction involved five units and made use of the 3-dimensional virtual reality electric circuit laboratory of the Open Learning and Laboratory Environment (OLLE). OLLE, as shown in figure 1, is an open learning environment that supports doing science by open experimentation and investigation (Psillos et al. 2008). Students had previously some familiarization in performing hands on and virtual experiments in introductory electricity but they had no involvement in designing experiments.

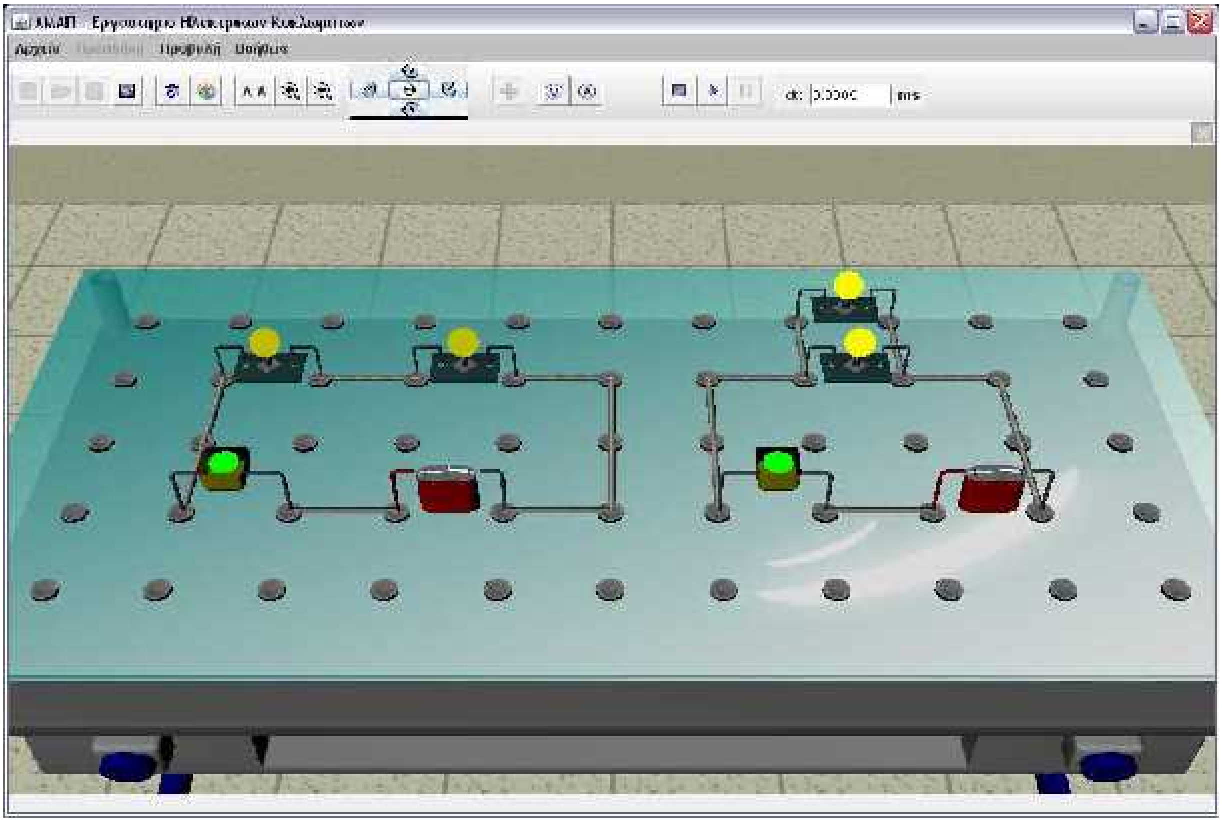

Figure 1. *The electric circuit laboratory of the Open Learning and Laboratory Environment*

According to the classification reported by Du et al. (2005) the guidance of the activities varied from cookbook lab (complete guidance) to challenge lab (guided inquiry). In the first unit (Ohm's law) students follow the directions of the worksheet and using the virtual laboratory equipment construct the given circuit and collect data (cookbook lab). In the second and third units (Kirchhoff's two laws) students followed instructions and using the virtual laboratory equipment construct the suggested circuit, collect and analyze data in order to (re) explore Kirchhoff's first and second law (structured lab). In the last two units (total resistance of resistors connected in series and in parallel) the students had to design the appropriate circuit and follow their own experimental procedure to take measurements and collect and analyze their data (challenge lab).

A post-test only design was applied since students had no experience in the design of experiments prior to instruction. It involved two assessment tasks of measuring the unknown resistance of two electric devices of OLLE at the end of the instruction (one with small resistance and another with large resistance). Students were asked to hypothesize on the outcome of their measurement, identify the variables affecting their measurement, list the devices needed for the experiment, design the appropriate circuit, describe the phenomena taking place and the experimental procedure, construct the circuit, take and analyze measurements, and evaluate their results. After the first task there was a short discussion on students' answers on the task in order to facilitate their thinking on their designs. An excerpt of the worksheet of the second assessment task is shown in figure 2.

Prediction

Do you think that a voltmeter resists the flow of electric current?

....

If so, is its internal resistance large or small? Why?

....

....

....

....

Prediction verification

In order to answer the above questions you will need to experimentally find the internal resistance of a voltmeter. When the voltmeter is connected to a circuit, which quantities do you need to know in order to estimate its internal resistance?

....

....

Which instruments would you use to construct an appropriate circuit for measuring and estimating a voltmeter's resistance?

....

....

....

....

....

Draw the schematics of a circuit with which you can realize the appropriate measurements.

What do you expect to happen when you turn on the above circuit?

....

....

....

....

....

Figure 2. *An excerpt of the worksheet of the second assessment task.*

The students' ability to design and perform experiments was evaluated by using a rubric of ten dimensions, (Anagnos et al. 2007, Lefkos et al. 2011). More specifically, the students were asked to hypothesize on the outcome of their quest (hypothesis forming), identify the variables which are relevant to the phenomenon under study (variable identification), list the devices that need to be used in order to answer their experimental question (devices and instruments), draw the schematics of the circuit to be constructed (device setup), describe what happens when their circuit operates (phenomena description), describe the data taking process (process description), construct the circuit in the virtual laboratory environment (object handling), make the necessary measurements (data acquisition), analyze their measurements (data handling), and record and evaluate their results (results recording and evaluation).

Students' answers were evaluated according to a 3-level scoring scale, similar to Lefkos et al. (2011). If an answer is missing or is incorrect the student gets 1 score point for that answer, if it is partially correct but incomplete the student gets 2 score points and if it is correct and complete the student gets 3 score points.

RESULTS

The results for the two evaluation tasks are shown in Figure 3. It is evident that most of the students are capable of performing correctly at least partially most of the parts of the two tasks (levels 2 and 3). In the second task students performed slightly better than in the first one though the difference was not statistically significant. This may be attributed to the discussion of the students' answers on the first task which took place before the second assessment task. The students reflected upon their mistakes and were able to produce higher level answers in the second task.

The best scores (highest percentage of students completing correctly a specific task) appear in the skill of object handling, where students had to construct their circuits, indicating a high familiarization level with the virtual equipment. This is to be expected since, as stated above, students were familiar with OLLE objects in introductory electricity prior to the instruction reported here. The worst scores (lowest percentage of students completing at least partially a part of the assignment) appear in the skill of hypothesis forming, especially in the second assessment task (large R measurement). This possibly occurs because after the discussion of their responses to the first task (small R measurement), students adapted their answers to that task and failed to make correct predictions for the second task (large R measurement). However, this mistake did not prevent them from carrying out the rest of the task and correcting their initial prediction

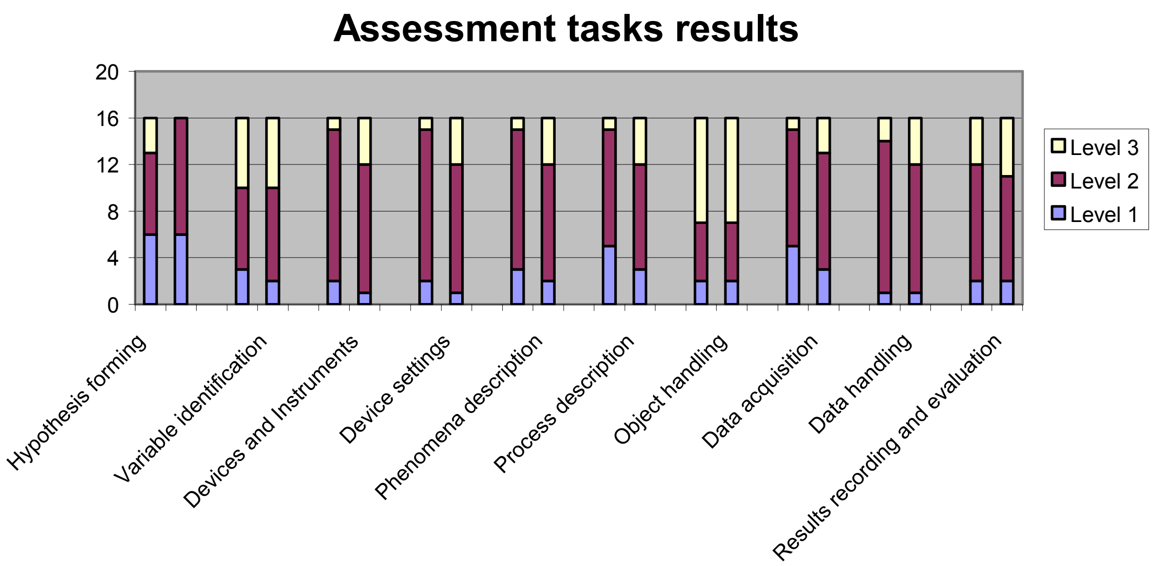

Figure 3. *Results for the first task (small resistance measurement, left bars at each skill) and the second task (large resistance measurement, right bars at each skill)*

DISCUSSION, CONCLUSIONS AND IMPLICATIONS

Our findings indicate that virtual environments and OLLE in particular may be effective in supporting the development of students' experiment design abilities. This can be attributed to several factors. First, they provide teachers with a powerful environment with which they can design, develop and apply inquiry-based investigative activities promoting scientific experimentation. Second, they provide students with a technologically rich environment with which they can interact by life-like manipulations of virtual objects being engaged actively in "doing science" and develop their experimental skills. Third, virtual environments present a simplified view of the world by omitting elements which are not essential to the phenomena under study. Thus students are relieved from time-consuming real lab manipulations (Psillos & Niedderer 2002) and focus their attention on the relevant objects and properties and are facilitated in making decisions about experiment design and applying it. As Lefkos et al. (2011) remark, virtual environments, like OLLE "can be considered as providing scaffolding to students to help them carry out such guided activities and develop design skills". We consider that our findings are in line with other results in other areas and extend these results to the field of electric circuits.

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HOW SECONDARY SCHOOL STUDENTS DESIGN, PERFORM AND EXPLAIN EXPERIMENTS ON THE RATE OF REACTION

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Abstract: The design of scientific experiments has the challenging issue that in some cases theoretical variables have to be translated into manageable and observable variables in the experiment. Secondary school students' achievements when they are faced to the design of an experiment to change the rate of a chemical reaction are studied. Pupils came from different schools to participate in an inquiry designed chemistry workshop at the university. Our results show that most of them are able to choose a correct variable and to identify more than one variable that could affect the rate of the reaction. We have also found that students design and perform a wide variety of experiments using both classical tools and microcomputer based laboratory equipment. A remarkable finding is that a considerable amount of learners have problems when transferring the concept of efficient collision to a different context. We suggest that presenting other contexts to students and analysing their outcomes can be helpful to design activities to scaffold students to achieve the competency of designing experiments.

Keywords: Design of experiments , transference of concepts between contexts, chemistry laboratory, control of variables, secondary school students.

1) BACKGROUND AND FRAMEWORK

Mastering procedures such as the design of experiments and the control of variables is an essential skill in scientific research, and so, it is a part of scientific literacy (PISA, 2006). To improve this knowledge, students need opportunities to practice selected skills, and laboratory activities if their design is accurate, can be a useful tool for this.

Research on the efficacy of chemistry laboratory activities have been conducted, and there is agreement that inquiry-centred tasks enhance meaningful student learning (Hofstein & Lunetta, 2004; Aksela, 2005; Hofstein, et al, 2005; Minster & Krauss, 2005; Tortosa, Pintó & Saez, 2008). Some studies have reported that younger pupils did not produce explanations for phenomena about chemical change that were consistent across contexts (Watson et al., 1997, Cackmacky et al 2006).

The design of scientific experiments has the challenging issue that, in some cases, theoretical variables have to be translated into manageable and observable variables in the experiment. It has been found that primary school students (Kanari & Millar, 2004) can design and interpret the results of science experiments in an inquiry-guided task, if with some inaccuracies.

One of the core concepts in chemical education is the *rate of reaction,* crucial in the chemical industry. We found no relevant research studies analysing how secondary school students use this concept to design chemistry experiments in an inquiry-guided task. In our work, students' achievements were studied when they were faced with the design, performance and explanation of an experiment on the rate of reaction.

Purpose and Research Questions

We understand that learning of a concept has occurred if there is the possibility to apply the knowledge to new situations. As we wanted to know to what extent students have learned the variables that control the rate of reaction, our research questions were:

-Are secondary school students able to apply the collision theory in a concrete context by choosing a variable in order to design an experiment to change the rate of a reaction?

-To which extent can students identify and take into account other variables that can affect the results of their experiment?

2) RATIONALE

The main interest of this work was to investigate the features of the design of chemistry experiments by secondary school students, especially the control of variables and the transfer of concepts between contexts. The design of experiments is crucial in scientifically literate pupils, and there has been little research on this issue in chemical education. Our students were taught the collision theory, and then were asked to design experiments to change the rate of a reaction. Students had to transfer their knowledge to a specific heterogeneous reaction that released a gas and, simultaneously, they had to consider the subsequent control of variables and choose adequate tools to obtain the required data. Students were scaffold with orienting questions in their worksheets.

3) METHODS

The research was conducted with 104 chemistry students (15-17 years) belonging to six groups from four secondary schools in Catalonia (Spain) attending a four-hour chemistry workshop in an inquiry-guided learning cycle at the university. Three of the groups were formed by students in their last year of secondary school compulsory education (15-16 years old) taking the optional subject “Physics and Chemistry” at their schools. The other three groups corresponded to pupils in their first year of post-compulsory education (16-17 years old) taking “Chemistry” as an optional subject.

Students had to solve a contextualised problem in which the understanding of the chemical concept “rate or reaction” was crucial for solving the task. The workshop was designed as a leaning cycle, starting with activities to make students’ previous ideas explicit. Students from different schools had been taught about collision theory differently. Pupils were asked to design and to perform an experiment in order to increase the rate of carbon dioxide production obtained by the reaction of calcium carbonate and hydrochloric acid. The author of this research was the teacher who monitored the sessions where students, working in small groups, received support. Former laboratory worksheets were tested with previous groups of students and changes were made to provide the students with adequate time and support. More specifically, pupils were guided with the following questions:

a) Which factor have you chosen to investigate its effect on the rate of reaction?
b) Design the experiment you would perform to test your ideas, and explain it briefly.
c) What are the other variables that can affect the rate of reaction?
d) What will you do to avoid their influence in your experiment?

We analysed the student’s answers to questions a-d in the lab sheets.

4) RESULTS

The analysis of the answers obtained to questions a), c) and d) are summarised in Table 1.

School		A n = 21	B n = 22	C n = 18	(15-16 years old) A+B+C n=61	D n = 23	E n = 11	F n=9	(16-17 years old) D+E+F n=43	Total n =104
Variable chosen	Temperature	11	11	10	**32**	4	5	3	**12**	**44** (42%)
	Concentration	5	--	3	**8**	6	2	4	**12**	**20** (19%)
	Surface contact	3	8	2	**13**	13	4	2	**19**	**32** (31%)
	Other/N.A.	2	5	3	**10**	--	--	--	--	**10** (10%)
Mention other correct variables		18	13	17	**48**	23	11	9	**43**	**91** (88%)
Mention incorrect variable (pressure)		6	10	5	**21**	20	0	3	**23**	**44** (42%)
Correct explanation of control of variables		11	10	11	**32**	19	8	4	**31**	**63** (61%)
Incorrect explanation of control of variables		0	0	1	**1**	3	--	3	**6**	**7** (7%)
No explanation of control of variables		10	12	6	**28**	1	3	2	**6**	**34 (33%)**

Table 1. Variables evaluated by students in their experiments on the rate of reaction between $HCl_{(aq)}$ and $CaCO_{3(s)}$

From this table, we observed that most students (90%) correctly chose the variables to test for their influence on increasing the rate of reaction: increased temperature, increased concentration of hydrochloric acid and increased surface of contact (calcium carbonate in smaller pieces). Most of the students (88%) mentioned the other correct variables. We observed that the frequency of the selection of each variable was similar in each group of older students, whereas the younger ones chose mainly temperature.

A remarkable result was that a considerable proportion (44%) of the students incorrectly stated that changes in pressure could affect the rate of the reaction. One possible explanation to this outcome may be the fact that, in the workshop, students were taught collision theory with the example of efficient collisions in gases (where pressure can vary the speed of the reaction) and they transferred this knowledge incorrectly to the new situation (the reaction between a solid and a liquid). Our results point out difficulties in transferring concepts between different contexts, as other authors have (Watson et al., 1997, Cakmakci et al 2006). Our results also suggest a difficulty in relating the macro and submicroscopic levels, as found by Justi (2002).

A great variety of answers were found in the analysis of question b: some students made drawings, other wrote text, some used microcomputer-based laboratory equipment (Tinker, 1996) and some used classical equipment. We found no relevant differences between the groups of students. An example of students' explanations, using classical equipment and microcomputer-based equipment, is shown in Figure 1.

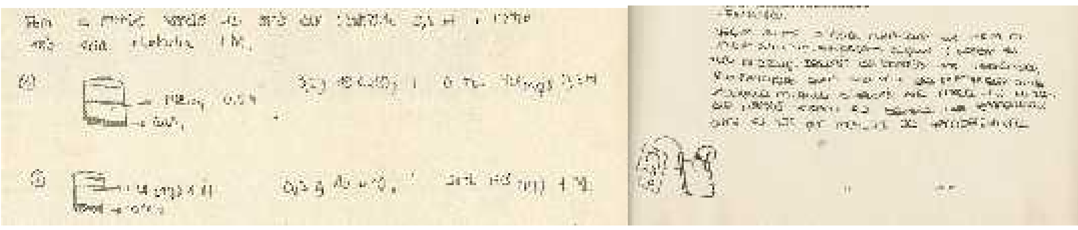

Figure 1. Examples of a student's explanation (in Catalan) when designing an experiment to test if a specific variable influences the rate of the reaction between $HCl_{(aq)}$ and $CaCO_{3(s)}$.

5) CONCLUSIONS AND IMPLICATIONS

From our results, we have found that when secondary school students are faced with designing an experiment on the rate of a reaction, the majority of students are able to recognise more than one variable which can influence the experiment. The way in which students explain the control of variables varies to a large extent from writing to drawing. More than half of the students performed the task correctly. We also observed that the correct explanation of the control of variables was done in a slightly higher proportion by post-compulsory students. We agree with other researchers (Cakmakci et al, 2006), interpreting this as a sign of general maturity in grown-up pupils. Finally, we detected a difficulty in understanding efficient collision and the factors that influence it in different chemical reactions, as nearly half of the students mentioned variables which would not increase the initial rate of the reaction. We think that more research should be done by presenting other contexts to students and analysing their interpretation of experiments in order to help students achieve competence in designing experiments.

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TYPES OF INTRA- AND INTERMOLECULAR BONDING: THE CASE OF GENERAL CHEMISTRY TEXTBOOKS

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Abstract: In this study we identify and compare the teaching of chemical bonding in terms of the ordering and extent of coverage of the various relevant concepts and bonding types. To this purpose, we examine a number of general chemistry textbooks. Fourteen books made the convenience sample for the comparison. Similarities and differences were identified with regard to the following aspects: presentation order of intra-molecular bonds; placement and method of presentation of inter-molecular bonds; the bond continuum; physical states and their connection with the types of bonding; metallic bonding; the octet rule; electronegativity and bond polarity; semi-covalent (dative covalent) bond. Almost all books present intramolecular before intermolecular bonds; more books start with ionic bond, than with covalent bond; most books refer to the covalent and ionic bonding continuum, while few books treat the two types as autonomous; electronegativity and bond polarity are presented within intramolecular bonding; most books consider only intramolecular bonding as true chemical bonding. Finally: most textbooks do not mention the semi-covalent (dative covalent) bond; most textbooks include the metallic bond. Regarding the intermolecular bonds, the books follow different orders of presentation, while some books pay more attention to hydrogen bonding. This article concludes with considering the way chemical bonding is treated by the states-of-matter approach (SOMA) of introductory chemistry.

Keywords: general chemistry textbooks, types of chemical bonds, intramolecular bonding, intermolecular bonding, chemical bond continuum

BACKGROUND AND FRAMEWORK

Chemistry education should aim at two main targets: to provide students with: 1) chemical literacy; 2) chemical culture. In addition, it must cultivate higher-order cognitive skills and reveal the process of science. It is therefore important to show that chemistry is not only a useful, but also an interesting and aesthetically enjoyable subject. The purpose of this study is to identify and compare the teaching of chemical bonding in terms of the ordering and the extent of coverage of the various bonding types and the relevant concepts. To this purpose, we examined a number of general chemistry textbooks.

According to Gagné (1985), learning tasks can be organized in a *hierarchy* according to complexity. The primary purpose of the hierarchy is to guide instructors so that they can "identify prerequisites that should be completed to facilitate learning at each level" (Kearsley, 1994). This learning hierarchy also provides a basis for sequencing instruction**.** Kearsley suggests keeping the following principles in mind: (1) learning hierarchies define a sequence of instruction; (2) learning hierarchies define what intellectual skills are to be learned; (3) different instruction is required for different learning outcomes.

Rationale: Teaching Chemical Bonding

Four general types of bonds are traditionally employed in the teaching of chemistry: ionic, covalent, molecular, and metallic. Each type is used with the aim to rationalize the properties of a group of compounds. This approach is due partly to the fact that it is deemed convenient for students, and partly to historical reasons. It also allows for the statement of well-defined questions for the exams. The approach leads to an oversimplification and a generalization, which constitute obstacles to conceptual understanding and good learning: there are many groups of modern materials that cannot be classified into any of the above four types of bonding.

Covalent and ionic bonds are often presented in a dichotomous manner as due either to the sharing or to the transfer of electrons. The case of pure covalent bonding appears in the case of homonuclear bonding. However, a pure ionic bond does not exist. In heteronuclear systems, bonding is better described by means of a continuous covalent-ionic scale. In addition in ionic crystals, the concept of molecule in the context of "two atoms bonded together by an ionic bond" does not exist: ionic bonding is extended instead across the three-dimensional crystal, so that any two neighboring ions of opposite charge are bonded (Taber, Tsaparlis, & Nakiboglu, 2011). The establishment of the above dichotomous approach hinders understanding of a more complex scale.

Traditionally, bond polarity is discussed in the context of covalent bonding only, and not as an integral part of bond polarity. The difference in electronegativity between the two atoms participating in a bond is used as a criterion for predicting bond type. The usual approach to metallic bonding (a lattice of metal ions in a sea of electrons) might contribute to oversimplification and generalization. On the other hand, the octet rule is another 'fetish' that hinders the understanding of molecules and bonds with more or less than eight electrons in the outer shell of the atoms. Finally, in most books covalent and ionic bonding is described as true bonding, while the Van der Waals bond and hydrogen bonding are presented just as 'forces'.

It is noteworthy that while in practice a theoretical approach to bonding is adopted as a rule, a teaching methodology that will be consistent with Gagné's theory (as well as other theoretical approaches, such as Ausubel's meaningful learning or active learning methods) requires the coupling of the theoretical models with experimental data. For instance, Nelson (1994) distinguished three "limiting types" of binary compounds: metallic, salt-like (ionic), and non-metallic, with each type being characterized by a given electrical character; these represent extremes, and most binary compounds fall somewhere in between these extremes.

Finally, a new 'bottom-up' framework for teaching chemical bonding has been proposed recently by the Weizmann team (Kronik, Nahum-Tami, Mamlok-Naaman, Hofstein, 2008)): a single atom—elemental principles: the chemical bond—fundamental principles; bonds—a continuum approach; structures; properties. A main feature is the continuum approach in dealing with bonds.

PURPOSE AND METHOD

In this study, we evaluate the presentation of chemical bonding in a number of general chemistry textbooks. In particular we look for similarities and differences with regard to the following: order of presentation of intramolecular bonds; the covalent/ionic bond continuum; ionic bond (energy diagram, the octet rule, crystal structure, properties, Coulomb's law, electrostatic nature, Lewis structures); covalent bond (energy diagram, the octet rule, crystal structure, properties, Coulomb's law, electrostatic nature, Lewis structures; electronegativity; the octet rule; semi-covalent (dative covalent) bond; metallic bond; order of presentation of intramolecular bonds; physical states and their connection or no connection with the types of bonding.

At the outset, we should state that the aim of this study is not to carry out an evaluation of the particular general chemistry textbooks. We are simply interested in looking for patterns. Fourteen general chemistry books were analyzed, making the convenience sample that was drawn from the Library of the University of Ioannina. The books are as follows:

1. Atkins & Jones (2001). Chemistry: Molecules, matter and change, 4^{th} edn.
2. Chang (2000). Chemistry, 6^{th} edn.
3. Ebbing & Gammon (1999). General chemistry. 6^{th} edn.
4. Gymer (1973). Chemistry: An ecological approach.
5. Kotz & Treichel (2003). Chemistry and chemical reactivity, 5^{th} edn.
6. Lewis & Evans (1997). Chemistry, 1^{st} edn.
7. Pauling & Pauling (1975). Chemistry.
8. Rosenberg & Schaum (1966). College chemistry, 5^{th} edn.
9. Schwartz, Bunce, Silberman, Stanitski, Stratton, & Zipp (1997). Chemistry in context / Applying chemistry to society.
10. Sherman & Sherman (1993). Chemistry and our changing world, 3^{rd} edn.
11. Silberberg (1999). Chemistry - The molecular nature of matter and change, 2^{nd} edn.
12. Spencer, Bodner, & Rickard (2008). Chemistry - Structure and dynamics, 4^{th} edn.
13. Timberlake (2002). Chemistry - An introduction to general, organic and biological chemistry, 8^{th} edn.
14. Whitten, Davis, & Peck (1999). General chemistry, 6^{th} edn.

RESULTS

Almost all fourteen books present intramolecular before intermolecular bonds.

Presentation order of intramolecular bonds:

- 10 books start with ionic bond, while
- 4 textbooks start with covalent bond.

Intramolecular bond continuum:

- 11 textbooks refer to the covalent and ionic bonding continuum.
- 3 textbooks treat the two types of bonding as autonomous types.

Ionic bond:

- Only 2 textbooks include the potential energy diagram for ionic bond.
- 10 books refer to the formation of the ionic bond, but only 4 use the octet rule to explain the formation of ionic bond.
- 7 textbooks refer to the accepted model that ionic compounds create crystal structures with ionic bonds.
- 5 books refer to lattice enthalpy.
- 8 books refer to ionization energy and electron affinity.
- 7 books refer to electronegativity and explain with it polarity of ionic bonds.
- Coulomb's law is included in 4 books.
- The electrostatic nature of ionic bond is discussed in 8 books.

- In 3 books, Lewis structures are discussed in connection with the ionic bond.

Covalent bond:

- 3 textbooks include the potential energy diagram for covalent bond.
- 8 books refer to the octet rule as the cause of covalent bond formation, while the remaining
- 6 books consider the octet rule as a guiding rule, and not as the cause of bond formation.
- 9 textbooks include that covalent compounds create molecular structures with covalent bonds
- 2 books refer to ionization energy and electron affinity in connection with covalent bonding.
- 6 books refer to electronegativity with the aim to explain covalent bond polarity, while
- 7 books refer to bond polarity in connection with polarity of intramolecular bonds in general.
- 2 books include Coulomb's law in connection with covalent bonding.
- Lewis structures are included in 7 books (with 1 book not mentioning the bonding electron pairs in covalent bond formation)

Additional features:

- 11 textbooks do not include the semi-covalent bond.
- 6 books refer to metallic bond after the study of intra- and intermolecular bonding.
- 4 books refer to the metallic bond after the study of intramolecular bonding, but before presenting intermolecular bonding.
- 1 book, while referring to the concept of metallic bonding, it does not invoke the term metallic bond. Finally,
- 3 books do not refer at all to metallic bonding.

Intermolecular bonds:

- 1 book presents intermolecular bonds without referring to their types;
- 4 books refer to the existence of intermolecular bonds but describe only the hydrogen bond;
- 9 books follow different orders the types of intermolecular bonds.

Physical states and chemical bonds:

- 4 books refer to physical states without any connection with bonding.
- 1 book refers to physical states after introducing the bonds.
- 4 books discuss physical states after the introduction of intra-, but before discussing intermolecular bonds.
- 1 book discusses physical states within intramolecular bonding.
- 1 book refers to intermolecular bonding when discussing the liquid state, while the two other physical states are discussed in a following chapter; on the other hand,
- 1 book refers to the gaseous state before introducing intermolecular bonding, while the two other physical states are discussed immediately afterwards.

CONCLUSIONS AND IMPLICATIONS

Almost all books present intra- before intermolecular bonds. Most textbooks present first the ionic bond; most textbooks refer to the covalent/ ionic bonding continuum; most books consider only intra-molecular bonding as true chemical bonding, while intermolecular bonds are described as *forces*. Bond polarity is connected directly with covalent bonding. In few cases bond polarity is discussed at the beginning or at the end of the chapter on bonding. Electronegativity is presented in the context of polar covalent bonds, and not always as an integral part of bond polarity. Differences in electronegativity of the bonded atoms are used for identifying bonding as covalent or ionic. In most books the octet rule is presented as a prerequisite for the realization of bonding both covalent and ionic. Finally, in few books ionic and covalent bonds are presented as autonomous bonds, while the rest emphasize the existence of both an ionic and a covalent character in the majority of compounds.

Conclusions for the ionic bond: In their study of the ionic bond, most textbooks refer to: the crystal structure of ionic compounds; the electrostatic nature of the ionic bond; the formation of octets; ionization energy and electron affinity. Also: most textbooks do not refer to: the octet rule, Lewis structures, and the Coulomb law; the lattice enthalpy; electronegativity; the potential energy diagram.

Conclusions for the covalent bond: In their study of the covalent bond, most textbooks refer to: the molecular structure of covalent bond; Lewis structures; the octet rule. Also: more textbooks in covalent bond than in ionic bond are talking about electronegativity and bond polarity. And in most textbooks there is no reference to the ionization energy and/or the potential energy diagram in connection with covalent bonding.

Finally: most textbooks do not mention semi-covalent (dative covalent) bond; most textbooks include metallic bond. Regarding the *intermolecular bonds*, the books follow different orders of presentation of the types of these bonds, while some books pay more attention to hydrogen bonding.

Bonding in the States-Of-Matter-Approach (SOMA)

Before we conclude, we will comment on the treatment of chemical bonding taken by the States-Of-matter Approach (SOMA) to introductory chemistry. In SOMA, there are three major units, namely: (A) Air, Gases and the Gaseous state; (B) Salt, Salts, and the Solid State; (C) Water, Liquids, and the Liquid State. A textbook has been written that adopted SOMA, and this book is presented and evaluated in another article of these Proceedings (Tsaparlis & Pyrgas, ESERA 2011 Proceedings). The structure of SOMA dictates the order of presentation of intermolecular and intermolecular bonds.

The elements and compounds which, under usual conditions, are in the gaseous state, have small and simple covalent molecules (H_2, O_2, N_2, halogens, noble gases, H_2O, O_3, NH_3, NO_x, CO, CO_2, gaseous hydrocarbons, H_2S, SO_2, HCl). It follows that we have to start with the covalent bond (Johnstone, 2000; Johnstone, Morrison, & Reid, 1981). In the case of the ideal gas, intermolecular forces are absent, but Van der Waals bonds and London dispersion bonds can be introduced with real gases. In this way, we deal quite early with both intra- and intermolecular bonds. In the unit of solids, we start with table salt, the ionic bond, and crystal structure. Later, we deal with molecular solids, metals and the metallic bond; hydrogen bonding is also mentioned in the structure of ice. Finally, in liquids, we return to London dispersion, Van der Waals, and hydrogen bonding; in addition, we deal with aqueous solutions of electrolytes, including acids, bases, and salts; here we distinguish between: on the one hand, the dissociation of ionic compounds into their constituent ions in water; and on the other hand, the complete or partial ionization of covalent compounds in water (strong and weak acids and bases).

Turning to the *implications* of the findings of this study, we emphasize the need for the treatment of the various types of intra- and intermolecular bonds as a continuum. Needless to add the need for more research in order to reach improved methods of teaching and learning about chemical bonding. We are of the opinion that the SOMA method fits intra- and intermolecular bonds in a logical manner and contributes to the bond-continuum approach; further research is also needed here.

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LEARNING SCIENCE THROUGH ENGAGING WITH ITS EPISTEMIC REPRESENTATIONAL PRACTICES

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Abstract: This group of papers explores the development of student understanding and application of the discursive tools of science to reason in this subject, as the basis for classroom practices that parallel scientists' knowledge production practices. We explore how this account of the disciplinary literacies of science can be enabled through effective pedagogies. The papers draw on research from Australia and Sweden that have overlapping agendas and theoretical perspectives including pragmatism (Peirce 1931-58; Dewey 1938/1997), social semiotics (Kress et al. 2001) and socio-cultural perspectives on language and learning (Lemke, 2004). The papers examine the role of language/multimodal representations in generating knowledge claims in science classrooms, the classroom epistemologies that support learning, and assessment practices from this perspective. A large body of conceptual change research has identified trenchant problems in conceptual learning in science, spawning long-standing and ongoing programs to identify pedagogies to address this. By redefining the problem in terms of language and representation, we aim to offer a way forward to support student engagement and learning in science.

Keywords: Student learning in science, representation, pragmatism, socio-cultural perspectives, epistemic

BACKGROUND, FRAMEWORK AND PURPOSE

Much conceptual change research has identified trenchant problems in conceptual learning in science, spawning various long-standing programs to address this (Treagust & Duit, 2008). However, conceptual change perspectives are also changing to accommodate complexities uncovered by recent research and new theoretical perspectives (Vosniadou, 2008). Recent work in cognitive science (Klein, 2006; Tytler & Prain, 2010) emphasizes knowledge and learning as fundamentally situated, strongly dependent on perceptions and perceptual processing (Barsalou, 2003) and on informal reasoning, including pattern completion, association, and model based reasoning (Lehrer & Schauble, 2006a). Part of this work recognizes the fundamental role of language and representation as constituting thought rather than being a by-product of internal, stable mental constructs. There is increasing interest in socio-cultural theories that frame learning in terms of induction into the discursive practices through which the science community generates and validates ideas about the world (Lemke, 2004). From this perspective, learning and knowing is not primarily thought of as the inculcation, through formal logics, of uniquely and verbally defined conceptual entities, but rather as a process of increasing mastery of the multi-modal discursive tools and practices used by the scientific community.

Researchers have focused extensively on learning through inquiry, in representing investigative processes of science in the classroom to capture student engagement through exploration of ideas. This symposium explores a pragmatist, semiotic perspective on teaching and learning that brings notions of product and process together. From this pragmatist perspective (Peirce 1931-58; Dewey 1938/1997), knowledge and learning derive their meaning from their use, and conceptual entities are profoundly contextual in nature. These ideas are captured in recent work on the nature of science in which the existence of an irreducible 'scientific method' has been questioned and science is seen as a human practice, responsive to the contextual communicative needs of research laboratories and wider communities of practice (Duschl & Grandy, 2008).

The three papers in this symposium are grounded in larger Australian and Swedish research programs exploring with teachers the implications of these theoretical ideas for teaching, learning and assessment in science. The projects are strongly grounded in pragmatist perspectives, drawing on Peirce (1931-58), and Dewey (1938/1997), and on socio-cultural perspectives that view learning as induction into the epistemic practices of science through its multi-modal discursive tools (Lehrer & Schauble, 2006b; Lemke, 2004). The programs are aligned broadly with social semiotic perspectives (Kress et al., 2001), but the Australian project in particular focuses on student generation and negotiation of representations as a basis for quality reasoning and learning (Ford & Forman, 2006; Greeno & Hall, 1997). In this way, student engagement with the epistemic practices of science is seen as a fundamental condition for quality learning. Thus, the symposium explores linking the epistemic practices of science, the nature of conceptual learning, and classroom epistemological processes, to enable quality learning.

METHODS

In each paper we report on empirical classroom results based on video capture of student and teacher interactions, and use discourse analysis to understand the nature of the interactions between teachers, student, and artefacts that lead to quality learning. In the Australian cases the data also included interviews with students and teachers, pre and post tests, and student-produced artefacts. The analyses will explore:

1. The key features of a pedagogy based on student generation and negotiation of representations, and how such a pedagogy works to support quality learning;
2. The possibility of using semiotic resources to establish continuity between proximate and ultimate scientific learning purposes; and
3. The implications of a representational perspective for assessment in science.

STUDY 1: LEARNING SCIENCE THROUGH REPRESENTATIONAL CONSTRUCTION

Background, Framework and Purposes

Learning science in school is now broadly understood as learning the literacies of a specific discourse community, using a range of subject-specific and general representational tools to construct and justify evidence-based claims about the natural world (Kress et al. 2001;

Lemke, 2004). Researchers in classroom studies where students were guided to construct their own representations of scientific ideas (Carolan, Prain & Waldrip, 2008; Ford & Forman, 2006; Greeno & Hall, 1997) have noted the importance of teacher and student negotiation of representational meaning and of students having opportunities to explore, elaborate, re-represent and coordinate representations to interpret science phenomena. There is growing evidence (Hubber, 2010; Hubber, Tytler & Haslam, 2010;) of increased student engagement and improved learning outcomes from these processes. This paper reports on aspects of an Australian project where the researchers worked with teachers to develop and validate a pedagogy based on student generation and negotiation of representations. Research questions include: 1) What are the key features of a pedagogy based on student generation of multi-modal science representations? 2) How does this pedagogy support student reasoning in science, and 3) What evidence is there that this approach improves students' conceptual learning?

Methods

The research team worked with four experienced primary and secondary teachers to develop a series of teaching sequences on science topics that the conceptual change literature has shown to present learning difficulties. The sequences focused explicitly on student generation and negotiation of representations related to key concepts. In working with the teachers over two years, we developed a set of pedagogical principles based on our experience and on the theoretical ideas described above. The teachers' practices, student-teacher interactions, and student activity and discussion were monitored using classroom video capture. Key lessons were coded using an emergent scheme generated using Studiocode software, to make apparent the patterns of pedagogical moves and to explore the key features that could be considered fundamental to a representation-intensive pedagogy.

Teaching and learning sequences were selectively transcribed and subjected to ethnographic analysis to identify the extent to which, and in what ways, the pedagogical principles were exemplified, and for evidence of ways in which the focus on representational clarification supported reasoning and learning about key science ideas. Students were interviewed about their learning, and teachers about their perceptions of the effectiveness of aspects of the sequence. Student workbooks were collected to provide a continuous record of representational work. Pre- and post- test data were analyzed for evidence of improved understanding, flexibility representation generation, and capacity to transfer ideas to other relevant phenomena.

Results

The pedagogy has the following key principles:

1.The sequencing of representational challenges involving students generating representations to actively explore and make claims about phenomena, involving a) identifying appropriate representations underpinning key concepts; b) establishing a representational need, and c) working towards alignment of student generated and canonical representations.

2. Explicit discussion of representations, including a) their selective purpose, b) group agreement on generative representations, c) form and function, and d) the adequacy of representations.

3. Meaningful learning through representational/perceptual mapping between objects/events and representations

4. Ongoing and summative assessment focusing on the adequacy and coordination of representations.

Moreover, analysis of the patterns of conceptual clarification and orientation, representational challenges, clarification and negotiation of representations, and explanation/resolution showed similar pathways for lessons but differences depending on year level, place of the lesson in the sequence, and topic.

Analysis of teacher/student exchanges and student artifacts demonstrated a strong alignment of the pedagogy with inquiry principles, but with strong framing of representational exploration leading to appreciation of canonical forms.

We argue that this constraint on inquiry offers a productive way forward for classroom practice that relates the exploratory, epistemic practices of science, needing to represent the canonical knowledge forms as a key target for science curricula. Lesson transcripts, interviews, and post-test results are used to show evidence of significant reasoning and learning. The analysis of reasoning is linked to the use of representations as epistemic tools in science knowledge-building, and draws on Peirce's (1931-58) triadic model of meaning making, and notions of affordances to identify the way representations selectively focus and constrain attention on aspects of the problem space. Teacher framing of the use of multiple, selective representations and student understanding of the partial and selective nature of representations will be illustrated.

Conclusions and implications

There is increasing agreement that learning involves a process of induction into specific discipline-based discursive practices, and is mediated by representations as the epistemic tools of science. This research represents a serious attempt to translate these theoretical insights into a practical classroom pedagogy that can effectively frame learning in science. This program has both practical significance for teacher practice and teacher education, and theoretical significance in bringing science classrooms and science practice into closer alignment. A re-interpretation of conceptual problems in learning science in terms of representational issues, and a program to translate this into a pedagogy, shows promise of addressing problems in learning science that are well established in the conceptual change literature.

STUDY 2: USING ORGANISING PURPOSES TO SUPPORT SEMIOTIC RESOURCE USE IN SCHOOL SCIENCE

Background and Aims

In this study we discuss how educational research in semiotics and on representation use in science classrooms can be supported by a pragmatically-oriented approach to science education research. The aim is to demonstrate a heuristic that can be used to support teachers in scaffolding students' conceptual learning and agency in science subjects. The unit of analysis is action and activities (including talk and the use of other semiotic resources), rather than mental entities, and hence important aspects of learning are studied as visible processes in communication and interaction as mediated by different semiotic resources and artefacts (Kress et al 2001; Säljö & Bergqvist 1997).

In this study we supplement earlier research within this field with the pragmatist notion about how the progression of learning can be understood as oriented by *proximate purposes*, which the teacher needs to make continuous with the *ultimate purposes* of an educational sequence jointly with the students (Johansson & Wickman, 2011; Wickman & Ligozat, 2011). These two kinds of purposes make up the *organising purposes* of a teaching sequence.
The ultimate purposes or aims belong to the new kinds of scientific practices with concepts that are not yet familiar to the students (here we illustrate the concepts of friction, motion and

force as such ultimate purposes of a lesson). The proximate purposes belong to activities where students are given more familiar topics to study and discuss. A proximate activity of relevance for the ultimate aim of learning about friction and motion is for instance why we have tyres on our cars. Dewey, (1938/1997) called such proximate purposes that make sense and give agency to the student *ends-in-view*. A key task for the teacher is to find proximate purposes that work as ends-in-view to the students and that the teacher also can make continuous with the ultimate purposes of the lesson. The ultimate purposes make sense to the teacher, but the teacher has to translate them and make the students understand how the activity with ends-in-view also deals with the ultimate purposes. The praxis of using ends-in-view is commonplace in teaching, although their continuity with more ultimate goals of science teaching is rarely examined by educational researchers. The concept of ends-in-view originates from Dewey's (1938/1997) thinking about progression ("growth" in Dewey's terminology) as creating continuity between the prior experiences of students (including their use of semiotic resources), the current situation, and the new kinds of practices, concept uses and semiotic resources that students are introduced to. Our research questions in this study are: (1) How are the students' and teachers' language use, semiotic resource use and experiences made continuous in two different classrooms? (2) How may a teacher use the organising purposes to support this continuity for learning in science?

Methodology

In this paper we analyze two teaching sequences. The first is from a Swedish Year 5 school class studying science (Johansson & Wickman, 2011), which give a full analysis of the conversations in the class. The ultimate learning purpose for the lessons is about how friction facilitates or impedes motion. The teacher introduces this through more proximate purposes. We have studied two such proximate purposes used by the teacher: 1) why cars have tyres, and 2) that a vehicle can continue to travel indefinitely if there is no resistance at all. Events in the classroom were filmed and transcribed. The second analysed teaching sequence is from an Australian study using representations as semiotic resources to introduce the concept of force in Year 7 (Hubber, Tytler & Haslam, 2010; Hubber, 2010). We coded situations in the classrooms as dealing with either proximate or ultimate purposes and the associated semiotic resources as *colloquial language, inter-language, and science language*. The idea of continuity between the every-day and scientific uses of language has been developed by Wallace (2004) and Olander (2010). As the method for analysing the continuity regarding the organising purposes effected by the semiotic resources and experiences related to in the classroom we used Practical Epistemology Analysis (PEA), which is based on Dewey's (1938/97) ideas, and broader investigations into language and action (Wickman & Östman, 2002).

Findings

The Swedish classroom study demonstrates how the teacher first creates a situation where the proximate purpose of *why we have tyres on our cars* functions as an end-in-view to the students and helps them to take part in the conversation. The predominance of student experiences and student language in the conversation helps make it possible for students to understand why we have tyres on our cars. A short excerpt from the conversation illustrates this:

Teacher:	But what did you have to say about this, why do you think that we have tyres on our cars then? That's interesting, is it not, especially now that different ideas are floating around? Yes!
Erik:	Because otherwise we won't get anywhere, I mean then we get a grip, because without, if you didn't have that rubber on the tyres, then you'd just move around, you wouldn't get any, anywhere.

However, during the rest of the conversation about why we have tyres on our cars the teacher does not relate the proximate purpose to the ultimate purpose, so the students are not offered the possibility of seeing how only certain aspects of what is treated from the proximate purpose are relevant to the ultimate one about friction. In the conversation the two organising purposes are not made continuous in the sense that the concepts of friction and motion are related to the student experiences and word usage (e.g. grip, move around) regarding why we have tyres on our cars.

Neither in the second situation, about *how a vehicle can continue to travel indefinitely if there were no friction*, are the proximate and ultimate purposes clearly related to each other in the conversations between the teacher and the students. This conversation starts like this:

Teacher:	So friction makes it, it stop, this resistance, so that it doesn't continue for ever. If there wasn't any resistance anywhere, air resistance like you have felt with the car and no resistance on the road or in any of these parts, then these vehicles when they are given a push, they would continue for ever.
Erik:	Would they do that then?!
Teacher:	Yes! If there wasn't any resistance anywhere. Then this force that the vehicle has received would continue for ever.
Erik:	What if there is an uphill slope?
Teacher:	Yes then there'd be resistance immediately, right.
Erik:	Yes, exactly!

The students do not construe relationships jointly with the teacher about how the experiences and words used by the students in relation to the proximate purpose also relate (or do not relate) to the ultimate purpose about how friction facilitates or impedes motion. The teacher uses the word friction and chooses the term *resistance* as an inter-language, but no continuity is established to the ultimate purposes, which allows the students to use their own chosen colloquial words, the inter-language concept of resistance, and the scientific terms friction and motion to make them continuous in communication and action.

This non-continuous situation is contrasted with the one in the Australian classroom concerning how a teacher introduces the topic of how forces affect objects (an ultimate purpose) with the help of a clay-like material, plasticine. The students were asked to change the form of plasticine (a proximate purpose) and to give the words that they can use to describe what they were doing with the plasticine, such as stretch and roll (colloquial language). Doing this task represents one proximate purpose, which is followed by others. Together with the students, the teacher then sorts their words under the headings of "pull" and "push" (inter-language) and how all their different changes to the plasticine can be understood as "pull" or "push", which together represent what physicists call "force" (science language). The students and the teacher then work to create diagrams using arrows (semiotic resource) that in a communicative way can help other students to form plasticine to a certain shape (to mediate action through semiotic resources). These arrows at the same time function as a sort of inter-language (arrows that show the direction of force in physics vs. arrows as directions for shaping the plasticine). When the teacher asks the students about the best choice of representation, student 2. highlights its purposefulness:

Teacher:	Which one of these representations worked well in explaining what was done?
Student 1:	John's because it showed you exactly what to do. Mine could have ended up anything.
Student 2:	It was more visual, you can actually see it is easier to actually see what you did. With the other ones you could make it in different ways.

The semiotic resources are used by the teacher in this Australian study in a way that helps to create continuity because 1) the proximate purposes (shaping plasticine and giving other students instructions about how to give it a specific shape) gives students an activity where they can see an end-in-view, and 2) the semiotic resources are formulated explicitly by the teacher together with the students in such a way as to create continuity between the ends-in-view and the ultimate purpose of teaching students about the concept of force and how it can be represented.

Significance of Findings

Students do not learn scientific concepts simply because the teacher adopts an inter-language, but rather the students use their own experiences and a variety of semiotic resources. The use of these meaning-making resources needs to be closely monitored in relation to the continuity it creates to the proximate purposes, ends-in-view, and ultimate purposes of lessons. Hence, teachers can use the two organising purposes as a heuristic to support science learning by planning for and monitoring their continuity in the sequence of classroom experiences of the students.

STUDY 3: IMPLICATIONS OF A REPRESENTATIONAL PERSPECTIVE FOR ASSESSMENT OF SCIENCE LEARNING

Background, Rationale

As noted by many researchers, and summarized by Osborne and Dillon (2008), current constrained assessment practices in school science often entail rote memorization in an information transfer model that fails to (a) measure the depth of student learning, (b) provide useful feedback to learners, and (c) match the richness of experiences and representational challenges faced by learners in the classroom, and by scientists in research teams. In supporting science education reform, Duschl (2008a, p. 278) argued that students should participate in "the social processes and contexts that shape how knowledge is communicated, represented, argued, and debated", where activities and tasks "make the students' thinking visible". However, the question of effective formative assessment practices that address directly the adequacy and development of students' representational choices remains under-researched. Hattie and Timperley (2007) and Black and Wiliam (2009), in their recent analyses of effective formative assessment processes, claimed various types of activities, such as sharing success criteria with students, classroom questioning, teachers' written feedback on student work, peer- and self-assessment by students, and formative use of summative tests, enhance subsequent student test performance. However, these prescriptions also tend to ignore addressing representational challenges students face in learning science concepts.

From previous studies we have identified various pedagogical principles that promote an effective focus on student-generated representations for learning in science (Carolan, Prain & Waldrip, 2008; Prain, Tytler, Waldrip & Hubber, 2009; Hubber, Tyler & Haslam, 2010). These principles suggest that teachers and students need to understand representational conventions and purposes and to assess their clarity and adequacy as evidence of students' emerging thinking, reasoning processes, and conceptual understanding. By implication, formative feedback from students and teachers needs to focus on timely judgments and guidance about processes or strategies for understanding representational tasks, redress misunderstandings, confusions, ambiguities and omissions. Formative feedback should also lead to strategies that enable students to self-regulate their next attempt at representation, or integrate multiple representations to show conceptual understanding.

Drawing on this literature, we aimed in this study to: (1) identify formative assessment processes in a science classroom where the teacher focused explicitly on student-generated representations, (2) identify changes, if any, in students' performance in summative topic testing after experiencing a representation-rich learning environment, and (3) consider the implications of these findings for current theory and practice in formative and summative assessment in learning science.

Methods

Our mixed methods research approach entailed collection and analysis of quantitative and qualitative data using case studies of two Year 8 secondary Australian science classes of like quality in terms of students' past performance in science, over a period of six months. Topics covered included nutrition, chemical equations, astronomy, particle theory and air pressure, and force. Students in each class participated in diverse interpretations and constructions of representations of science concepts and processes. These included group and whole class talk about different aspects of the topic, interpreting teacher notes and diagrams, re-representing three-dimensional practical activities in two-dimensional formats, making sense of and re-representing video and other resources used to supplement classroom activities, participating in virtual web-based experiments using tables and graphs, and student construction of their own two-dimensional representations of practical investigations. Data sampling and analysis included observation and videotaping of the teachers' classes, analysis of classroom interactions, teacher and student interviews, examples of students' work, and analyses of students' examination scripts. Scripts were analyzed in terms of students' use of appropriate scientific vocabulary, complexity of sentences in scripts, text readability, number of representational modes used by students in relation to quality of text, and the extent to which modes were integrated through explicit textual ties or embedding.

Results

Analyses of the teachers' focus in formative assessment processes indicated a shift from assessing the correctness of responses to interpreting their thinking as evident in their representational decisions, revisions, and queries. The teachers no longer assumed that students understood representational conventions or had relevant prior conceptual understanding, but focused on interpreting their accounts of their representations and their reasoning as it became apparent from how they represented and coordinated their emerging ideas. The teachers increasingly focused on assessing students' knowledge in terms of their capacity to construct, coordinate and judge the adequacy of their representations in terms of their fit for purpose and persuasiveness.

The teachers diagnostically established students' initial understanding of the concepts of motion, and in subsequent lessons they used formative techniques to explore what was the current state of student understanding and to prompt students to explore alternative perspectives, largely through the use of appropriate questions and judicious use of activities to promote new thinking. This process was influenced by (a) prior understanding of the need to build a coherent account that links properties/behaviour of objects with plausible claims, (b) prior experience with science class methods and the need for accurate measurement of change as the basis for hypothesizing, (c) informal qualitative reasoning around patterns of observed phenomena, and (d) everyday language use of technical terms of topic and everyday ontological accounts of causality. This re-representation work also drew on perceptual contextual clues, as student attempted to identify key observed aspects of phenomena for investigation, as well as problems/gaps/inconsistencies, and also evaluated the adequacy of their own views compared to what they observed with other groups.

The teachers noted that the focus on representational adequacy had the following effects on their formative assessment practices: (1) their feedback and student discussion were more specific and focused on particular features of the representations. (2) teacher and student feedback focused on the precise meaning (or meanings) as well as limitations of meaning entailed in different representational choices, and (3) they focused far more on students' intentions and questions than in past approaches.

Analyses of the students' topic test performance across a range of topics identified the following patterns:

1. Students' scripts provided more detailed responses than was customary. These responses contained more use of appropriate scientific vocabulary, more words, and the concepts were written about at a higher level of readability.
2. Students were more likely to use diverse representational modes, and to incorporate effective textual ties, such as arrows, captions and labeling to link modes. Students were more likely to realize, in subsequent interviews, the limitation of their representation as a complete answer.
3. During interviews, some students explained that their representations allowed them to show properties and understandings that were difficult to verbalize, and that this use allowed them to communicate key ideas more easily.
4. Students were still partly bound by examination expectations, in that they perceived that teachers gave more weight to written responses than to other representational modes.

Conclusions/ Implications

The literature on formative assessment largely draws on cognitive approaches to learning as individualistic information processing, tending to ignore semiotic theories of disciplinary meaning-making, epistemic theories of how science knowledge is produced and validated, and socio-cultural theories of learning through group processes. Our study suggests that a focus on student representational challenges, informed by these perspectives, can provide a practical and valuable focus for formative and summative assessment in this subject. However, our study further suggests that teachers need considerable professional learning support to change to the orientation and strategies proposed in this paper.

Summary of findings

The first paper, '*Learning science through representational generation/negotiation'*, explores the development of a pedagogy based on student generation and negotiation of representations. Based on work over a number of years, with a small number of teachers and key science topics, four key principles of this pedagogy are described and student and teacher data is used to establish the quality of the learning and the issues for teacher change in adopting such a pedagogy. Peirce's (1931-58), triadic model of meaning making is used to explore the role of representation in learning.

The second paper, '*Using organising purposes to support semiotic resource use in school science'*, uses Dewey's notion of 'ends in view' to explore how the immediate, proximate purposes of science activities might be made continuous with more abstracted, ultimate goals of science learning. A practical epistemological analysis of two classroom sequences was undertaken, drawing on the ideas of Dewey (1931-97) and others to show how both students and the teacher used semiotic resources based on more proximate purposes, but how one teacher made these continuous to ultimate purposes. The paper explores how we might create continuity between these different levels of purpose in science lessons.

The third paper, '*Implications of a representational perspective for assessment of science learning*', critiques current perspectives on formative assessment from a representational, pragmatist perspective. It uses case studies of teachers working with lower secondary school students to examine the implications of a representation-intensive pedagogy for both formative and summative assessment, and shows how such a focus can result in more complex student responses on tests, and improved learning. The implications for assessment of this representation-intensive pedagogy are explored.

Overall Conclusions and Implications

In this symposium the practical implications of a pragmatist, semiotic perspective on learning is explored in relation to the development of a coherent pedagogy, to the nature of quality learning, to aligning resources to create continuity between proximate and ultimate purposes, and to conceptualizing and enacting improved assessment practices. Across these explorations, which are grounded in video capture studies of real classrooms, the symposium aims to signal ways forward for school science that bring together the epistemic practices of the discipline itself and the learning needs of students. In this, we see the symposium as an important contribution in helping us move beyond traditional ways of looking at science learning and knowing, to offer a coherent account of broader socio-cultural perspectives on learning.

Discussant: Richard Duschl, Penn State University, USA

Learning science via engagement in epistemic practices has become a very promising line of research. Significant evidence suggests that engaging pupils in growth-of-knowledge practices such as argumentation, modeling and representation promotes important discourse and reasoning opportunities that facilitate 1) students' conceptual learning and 2) teachers' adaptive instruction decision making to guide assessments for learning. Further, when the learning goals build and refine knowledge claims employing arguments, models, and representations, important critique and communication criteria come to the fore. Listening to and examining the talk, models, mechanisms, drawings and visualization help make children's thinking visible; to themselves, to peers and for purposes of teacher' instruction-assisted learning. The Australian research program where lessons are infused with copious use of representations with subsequent links to literacy practices is clearly demonstrating a positive impact on science learning and instruction. The application and connections of didactics and curriculum theory by Anna Maj Johanesson and Per-Olf Wickman to help frame the learning progressions basis of the research does so in important and effective ways. In pushing the agenda, I offer up six challenges to the symposium participants and the broader ESERA research community.

Challenge 1. Extending & Scaling Research in Language & Representation on Learning

There is a need to consider the communication of ideas and information to learners as well as the coherent sequencing of curriculum and instruction aligned to assessments. A review of the language and labels adopted by researchers reveals a wide almost disturbing use of terms and phases. The first challenge is to establish a common language among researchers where the ambiguity of meanings is minimized. Consider a current sample of associated terms and phrases common among scholarly publications:

1) Curriculum Units as: Learning Progressions, Teaching Sequences, Teaching Experiments, Learning Trajectories, Immersion Units, Inquiry Units, Lessons, Activities;

2) Intertwined Epistemic Products as: Evidence=Models=Theories= Explanations

3) Labels for Learning progressions, such as Lower to Upper Anchors; Proximate to Ultimate Purposes, Intermediate Levels, Messy Middle, Construct Map Levels, Meta-representations, Benchmarks, and

4) Terms for Scientific Products/ Practices, such as Modeling, Drawings, Data modeling, Representations, Inscriptions, Visualizations**.**

Challenge 2. Extending & Scaling Research in Cognitive & Social Psychology

Various perspectives compete on learning. The divide is between scholars who maintain extreme positions regarding *cognitive (information processing)* and *situative (sociocultural constructivism)* learning theory perspectives, eschewing the middle ground (c.f., Duffy & Tobias, 2010). The field needs some agreement on models of learning that recognize humans as individual cognitive agents functioning within social networks. Among the set of papers presented in this symposium, there are tensions regarding meanings of learning. Since the mid-1990s research has shown that effective learning environments are based on the following cognitive (CP) and social psychology (SP) precepts (Glaser, 1995):

Structured Knowledge (CP) Instruction should develop conceptual structures to support inference & reasoning;

Prior Knowledge (CP) Learner intuition is a source of cognitive ability that supports & promotes new learning;

Metacognition (CP) Reflection on learning, meaning making & reasoning strategies provides learners a sense of agency;

Procedural Knowledge in Meaningful Contexts (CP) Learning information should be connected with its use;

Social participation and cognition (SP) Social display of cognitive competence via group dialog helps individuals acquire knowledge and skill;

Holistic Situation for Learning (SP) Competence is best developed through cognitive apprenticeship within larger task contexts; and

Make Thinking Overt (SP) Design situations in which the thinking of the learner is made apparent and overt to the teacher and to students.

Might we not agree to these or similar foundational precepts and then show how representations and other discourse practices can aid learners to build and refine models and explanations. Where students' work samples are used as assessments to guide learning and policy decisions, the research and policy communities need to come to agreement on viable models of learning (Gitomer & Duschl, 2007).

Challenge 3. Extending/Scaling Research on Coherence & Resonance in Assessment

Student representations during instruction can provide 'making thinking visible' opportunities that teachers can use to guide decisions for adaptive instruction. The established 'accountability' agenda of measuring achievement with high stakes tests competes with newer 'classroom assessments' agenda of evaluating learning for purposes of guiding/adapting instruction to advance learning. The research on using representations is presently focused on 'Assessment for Learning'. To address the coherence problem, the research needs to also study the use of representation in the 'Assessment of Learning' as well as the delayed and immediate logistics of using representations for 'Assessments for Learning' with external and internal audiences.

Challenge 4. Extending & Scaling the Research into Instructional Practices

A long and strong tradition in science education research has focused on conceptual change. Children's thinking is surprisingly sophisticated in some domains, mirroring adults' ideas, although lack of key conceptual details have been variously labeled misconceptions, alternative conceptions, and naive conceptions. However, children also have sound intuitions from which productive foundational platforms of learning can arise (Duschl, Schweingruber, Shouse, 2007). The key to conceptual change learning is establishing a coherent sequence of learning accompanied by an alignment of Curriculum–Instruction–Assessment. A recommendation from the research synthesis report *Taking Science to School* (Duschl, Schweingruber, Shouse, 2007) is to coordinate instruction around learning progressions that, in turn, focus on core science ideas and scientific practices. Tytler and colleagues have begun to make this important transition in the research programme (one I strongly endorse) as seen in their partial list of teaching principles to enact representation use.

Challenge 5. Extending & Scaling the Research in Data Modeling

The symposium papers emphasize the role representations have on concept learning. An important component of science learning no doubt but insufficient if left unconnected to the evidence used to establish the explanatory claims. The current focus is to pursue the goal of 'using knowledge' in building and refining models and explanations. Thus, developing scientific practices across the grade span is paramount to learning, communicating and evaluating science knowledge claims. An underrepresented focus in both mathematics and science education is data modeling and the accompanying roles of data, chance, and inference. (Lehrer & Kim, 2009) Mathematizing nature is a central dynamic of science inquiry but an oft-underrepresented part of instruction in science education. The message is that instructional time needs to be given over to students' engagement in such refined practices as inventing, constructing, and refining 1) measures, 2) units of measures, 3) representations of measurements, 4) models of chance events, and 5) inferences regarding future data gathering and modeling.

In our research (Lehrer & Schauble, 2004; Lehrer, Schauble & Lucas, 2008) we are finding that instruction must involved learners' with:

(1) Prolonged experience with phenomena,

(2) Posing and revising questions – working over time to make explicit and refine criteria for good questions,

(3) Parsing objects and events into attributes that bear on the question,

(4) Considering/debating means of measuring attributes in ways that support an initial model of the phenomenon (considering the measure properties of those attributes,

(5) Generating/creating data (observing its measure qualities, reliability, etc.

(6) Structuring data (patterns are made, not found),

(7) Interpreting data as evidence – model construction,

(8) Model testing against the original phenomenon & new cases,

(9) Generation/entertainment of alternative models,

(10) Evaluation of model fit, and

(11) Model selection/revision.

The point is that most of the above steps involve types of representations that go well beyond the concept focused drawings that currently characterize the research from the symposium papers. Measurement and data modeling must be central components in science representations precisely because they are central to claims of evidence and explanation.

Challenge 6. Extending/Scaling Research on Attainment of Communities of Practice

A focus of my research beginning with Project SEPIA (Duschl & Gitomer, 1997) and extending to research on argumentation (Duschl & Osborne, 2002) and on inquiry (Duschl & Grandy, 2008) has been the design of learning environments that establish epistemic learning communities (Duschl, 2008; Duschl & Jimenez Aleixandre, 2012). The research on the use of representations in science learning found in this symposium's papers make important contributions to understanding the design of learning environments. However, much more work needs to be done on the whys to engage children in the production and teachers in the assessment of various contexts for making thinking visible; e.g., drawings, models, mechanisms, stories, explanations, establishing criteria, measurements, data modeling, evaluating chance, and drawing inferences.

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Mathematics in Physics: Analysis of students' difficulties

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Abstract: The deep interrelation between physics and mathematics is an important fact to understand the success of physical science. Therefore it also influences classroom teaching which leads to additional problems due to mathematical difficulties and knowledge transfer. The teaching and learning of physical concepts seems to be hindered or even neglected. But could not mathematics be used supportively for a physical understanding? In order to approach this question it is important to carefully analyse the difficulties students experience while dealing with mathematics in a physical context. With this aim we observed 15 to 16-year old students from different schools of higher education. They worked at an interactive whiteboard on special physical-mathematical tasks which were designed in order to address the translation process between math and physics. Findings suggest that students focus on a technical use of mathematics. Especially understanding the connection between formulas and physical meaning seems to be problematic for most students. Therefore the conceptual meaning of mathematical descriptions in physics should be stressed in classroom teaching.

Keywords: Mathematics in Physics; Mathematization; Technical and structural skills; Mathematical Modeling; Knowledge Transfer

INTRODUCTION

> "Our previous experience justifies the belief that nature is the realization of the most basic mathematical thoughts. […] Experience remains certainly the sole criterion of usefulness of a mathematical structure for physics. But the truly creative principle is in mathematics." (Einstein, 1956, p. 116, our translation)

The quotation by Einstein sheds light on the deep interrelation between mathematics and physics. It is not the technical toolbox mathematics provides but rather the creative aspect producing new insights into physical structures that hints at a deep conceptual relation between both sciences. Under the perspective of discussions about the importance of "Nature of Science" for science teaching (Lederman, 1992), the conceptual entanglement between mathematics and physics should also have consequences for the teaching and learning of physics. The way theoretical physicists use mathematics, i.e. for modeling and investigating physical behavior, is also an important aspect of the nature of physics.

The importance of taking care of mathematical problems in physics education is also supported by research findings related to knowledge transfer. Generally it can be stated that transfer does not succeed to the desired extent, since knowledge and understanding is acquired context-specific (Brown, 1989). That implies that also the transfer of mathematical knowledge into physics domain can not be expected to happen automatically. On the contrary, it can be suspected that transfer form mathematics to physics is an especially difficult case as there are large differences in the use of and approach to mathematics by physicists. The use of mathematical language in physics differs in many ways from its use in mathematics (Redish, 2005).

On the other hand, the problems and difficulties arising with the use of mathematics within physics education must not be ignored. The objection that the application of formulas and calculations would hinder an understanding of physical concepts, lead to routine and "senseless" computing activities and brings additional mathematical difficulties with it, has to be taken seriously. However, one can assume that these problems stem in large part on the way in which mathematics is involved in physics teaching. Already Richard Skemp, a pioneer in mathematics education research, pointed out the difference between instrumental and relational understanding (Skemp, 1976). By focusing on instrumental skills like rote manipulations and learning rules, it is not possible to achieve a deep (relational) understanding of mathematical concepts. But especially for knowledge transfer a relational understanding is indispensable. Therefore, it is particularly important in physics classes to stress this kind of understanding of the relationship between physical behavior and mathematics.

THEORETICAL FRAMEWORK

A deep analysis of the role of mathematics in physics leads to the distinction into a technical and a structural role. Whereas the technical role describes the tool-like use of mathematics (e.g. calculating numbers), the structural role represents the close connection between physics and mathematics and their structural entanglement (e.g. the possibility to predict new physics from mathematical equations). In classroom situations the technical skills seem to be dominant, although the structural skills – e.g. mathematizing and interpreting – allow a meaningful use of mathematics. Moreover, a focus on the structural role of mathematics would be more in line with the nature of physics than the current instrumental use of mathematics (for a deep investigation of this issue and the derivation of a corresponding didactical model, see Uhden, Karam, Pietrocola & Pospiech, 2011).

A shift in the teaching practice towards the structural skills, and thereby towards the translation between physics and mathematics, requires the consideration of relevant didactic concepts. With the translation to and from mathematics the so called "Grundvorstellungen" (vom Hofe, 1992) – a theoretical concept used in mathematics education research to describe the translation between ideas or meaning and mathematical operations – emerge as they mediate between the mathematical and physical world. The term "Grundvorstellungen" might be best translated as "basic ideas" or "mental models". It refers to mathematical objects (i.e. mathematical operations, symbols etc.) and the ideas and conceptions connected to them. For example, a basic idea of "addition" can be understood as a sum of contributions, i.e. the operation of adding two amounts to get the whole amount as a result. On the other hand, one can think of "addition" as changing an initial state to a final state – as it is the case for describing changes in temperature. Obviously there is not only one correct basic idea of a mathematical operation. Rather it is important to activate the basic idea corresponding to the specific problem one deals with. Therefore one needs to have more than one basic idea available for activation. Enabling a flexible use requires experience and knowledge based on comprehension or, in other words, a relational understanding.

In the physical context these "Grundvorstellungen" have to be connected to an understanding of the physical concepts and be activated in accordance to the physical situation. Sherin (2001) investigated the meanings college students assign to formulas and classified them as so called "symbolic forms". A symbolic form is an entity in a formula which is associated with a corresponding physical behavior, e.g. a fraction stroke with a variable in the denominator means that the resulting behavior is inversely proportional to this variable. But as it is the case with the "Grundvorstellungen", there also exist more symbolic forms for one formal structure. Sherin claims for ongoing research in the same direction with students at a younger age (i.e. high school and secondary school) and for teaching strategies which strengthen the use of symbolic forms. Also an in-depth analysis of its interplay with students' strategies and difficulties is still owing.

RESEARCH DESIGN

The delineated argumentation leads to the main research question which needs to be answered by a qualitative study: What kind of difficulties do students have with mathematical reasoning in physics?

For animating the students to use structural skills and for investigating the resulting difficulties students experience thereby, we developed special mathematical physics tasks in order to address different aspects of translating between physics and mathematics. By working with these tasks the students are challenged to actively carry out the translation and to establish the connection between mathematics and physics not on a calculational but on a meaningful basis. More specifically the tasks contain amongst other aspects

- the creation of a formula on the basis of physical reasoning
- the interpretation of the special cases of a formula
- to draw conclusions based on a formula for physical behavior
- explaining the meaning of a formula

The theoretical assumptions about the nature of the connection between physics and mathematics, as exposed in the model by Uhden et al. (2011), guided the construction of the tasks. The degree of difficulty was validated by the observations made in the pilot study which also gave hints for improvements and additional ideas. The physical topic is mechanics due to the fact that this is the topic with the highest degree of mathematics involved in secondary school.

In total 30 students from different schools of higher education in Germany (“Gymnasium”) were invited to work on the tasks. The students are from class level 9 and 10 – i.e. 15 to 16-years old – and their school grades indicate a selection of mainly good students, but with more satisfactory grades than very good ones.

As the students worked in pairs at an interactive whiteboard we were able to conduct the observation without a video camera because the whiteboard provides the possibility to record the speech and writings simultaneously. The students were requested to discuss the problems with each other and get a joint solution in order to animate them to speak aloud and express their ideas and thoughts. This makes it possible to follow their lines of reasoning and thought processes to some degree. The recorded speech was transcribed and placed in relation to the writings. The transcripts were then evaluated according to the framework of qualitative content analysis (Mayring, 2008).

RESULTS

The observed difficulties were categorized along 4 main categories (which were each divided into subcategories):

- Mathematical understanding
- Superficial translation
- Connection between formula and meaning
- Interference with intuitive notions

The category “Mathematical understanding” refers to pure mathematical difficulties where no explicit connection to physics can be observed. That can pertain to problems with mathematical reasoning or to the already mentioned basic ideas. Nevertheless, these kind of difficulties have influences on the physical argumentation: If an increase in the denominator

leads to an increase of the whole fraction, the interpreted physical behavior will also be wrong.
The category "Superficial translation" is related to a strategic aspect. The established subcategories indicate that the connection between physics and mathematics is guided by superficial criteria. For example, for many students the association of formulas and units seems to be based on rote learning and the formula v=s/t is used once velocity is mentioned, no matter what physical circumstances are present.
The "Connection between formula and meaning" is an essential category that is in close correspondence to the mentioned symbolic forms (Sherin, 2001). The classified difficulties demonstrate a severe lack of understanding of equations and its related physical meaning. For example, the role of physical magnitudes as being a function, parameter, variable or constant seems to be confused or disregarded by some students. That led to discussing the influence of a function on a parameter with the result of confusion.
The category "Interference with intuitive notions" includes that students reject an actually successful connection between physical and mathematical argumentation due to implications that are in contradiction to their intuitive notions. If, for instance, the physical description is not understood as an idealization, the (idealized) mathematical results are considered as unrealistic, leading to a shortened interpretation of the results.

IMPLICATIONS

The outlined difficulties are a plea for a change from the technical to the structural mathematical skills in physics teaching and learning. Especially the observed superficial translation seems to be cultivated by a focus on a technical use of mathematics. And also the mathematical understanding can be assisted by teaching structural skills without delegating this task to mathematics education.
Furthermore, the categorized difficulties with the translation between formula and physical meaning offer the possibility to be addressed explicitly in the classroom in consistence with the symbolic forms. That could help building the foundations for a meaningful use of mathematics in physics teaching. Tasks that address the connection between physics and mathematics, as well as a general qualitatively oriented use of mathematical structures, are further possibilities to stress and support the understanding of structural skills.

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PUPILS' VIEWS ABOUT EXPERIMENTS IN SCIENCE

NATURE OF SCIENCE TAUGHT WELL-DIMENSIONED, AUTHENTICALLY, EXPLICITLY AND REFLEXIVELY IN PHYSICS INSTRUCTIONS

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Abstract: Young peoples' views about experiments in research and education have rarely been addressed in science education research despite the fact that experimental work is a main scientific method. The study presented in this article therefore focuses on this problem and assesses students' believes about experiments and investigates the effectiveness of an explicit instruction that teaches both, physics and nature of science (NoS) content. In a "pre-post-follow-up-design", more than 200 pupils aged between 16 and 18 years participated in an empirical exploratory study at the Ruhr-University Bochum, Germany. The results show that young people hold a variety of inadequate and only some adequate views about experimental work. Further, it is possible to change pupils' views about NoS in one-day-interventions as long as the NoS focus is well-dimensioned and an explicit topic of reflexive discussions.

Keywords: nature of science, views about experiments, views about scientists, explicit instructions, scientific inquiry

INTRODUCTION AND THEORETICAL BACKGROUND

Pupils' and students' views about the construct "nature of science" (NoS) are a well-known issue in science education (review e.g. in Lederman 2007). The results of research allow the conclusion that pupils' views about the NoS are more or less inadequate concerning different NoS-aspects such as the role of scientists, the epistemological status of knowledge aso. However, young peoples' beliefs about experiments in research and education have rarely been addressed despite the fact that experimental work is a main scientific method.

Besides assessing students' views about NoS, an important question is, how effective students' views changing instructions should be designed. Studies allow the conclusion that adequate beliefs about NoS cannot be conveyed without being made an explicit topic of discussion (Höttecke 2001, Lederman 2006). Further, to be able to change pupils' beliefs, the educational objectives have to be well-dimensioned. This essentially means that "only" parts of the huge NoS-field – as well as of the physics field – can be made a topic of discussion (Uhlmann & Priemer 2009). Finally, NoS- independent research in education shows the importance of authenticity and reflexivity (Siegel 1989) in instructions.

Both, the need to investigate pupils' views about experimental work in science as well as fruitful ways of discussing the role of experiments with students, led to the following research interest.

RESEARCH QUESTIONS

Which views concerning scientific experiments in research institutions in contrast to experiments carried out at schools do students aged between 16 and 18 have, and how do their views change if they take part in a well-dimensioned, authentic, explicit and reflexive project addressing aspects of the Nature of Science?

DESIGN OF THE STUDY

The design of the NoS-project

In order to address NoS in school instructions, a six hours science project with two focuses for pupils has been implemented. One focus lies on plasma physics, more precisely on the physics of plasma spheres and on the spectroscopy of the contained gases. The other focus lies on the epistemological status of experimental work, e.g. the differences of experiments carried out at schools and, in contrast to this, scientific experiments. The organigram in figure 1 shows further categories discussed in this project.
Apart from experimenting by themselves, pupils also actively communicate with scientific faculty members in interviews about physics content and about various ways of gaining knowledge (Uhlmann & Priemer 2011). They furthermore get the possibility to observe, discuss and learn more about real scientific experiments in laboratory tours.

figure 1 NoS categories

The design of the empirical investigation

In a "pre-post-follow-up-design", more than 200 pupils aged between 16 and 18 years participated in an empirical exploratory study at the Ruhr-University Bochum, Germany. To measure their views about the nature of experiments as well as their views about scientists, a paper-pencil-test had been developed and was now used: BoFEx (Uhlmann & Priemer 2011). Furthermore, a sub-dimension of the VASS (Views About Science Survey, Halloun 2001) was used for triangulation. Several control-variables, such as "content knowledge in general" and "content knowledge in plasma physics" were gathered with additional instruments. The follow-up-test took place three months after the project. The results were evaluated by using the standard tools for descriptive statistics.

RESULTS

A) Students had adequate beliefs about the role of experiments concerning different aspects. For instance, the pupils did not believe in the myth about the "lonely scientist" even before the project had started. The participants knew that scientists organize themselves in "scientific communities" to be able to work more effectively. Adequate views also occurred in the answers to socio-cultural questions. Here, the majority of the pupils for example believed that the development of scientific experiments was independent from the country the scientist lives in, the language he speaks, the religion he believes in etc. Moreover, an above-average amount of pupils stated that even scientists doubted their experimental results.
The participants' views concerning most aspects were, however, rather inadequate. The duration of scientific experiments, for instance, was evaluated in a too unreflected way. Common durations, known from typical school experiments, for instance, of 45 minutes, were often mentioned. Before the project, the participants obviously did not differentiate between "typical" experiments at school and scientific experiments. Apart from that, the pupils seemed to predominantly think that experiments always referred to hypotheses, pure explorative phases were rather unknown. Furthermore and in conformity with other surveys (e.g. Aikenhead 1987; Driver, Leach, Millar & Scott 1996; Edmondson & Novak 1993), evidence of naive realistic beliefs was found. The majority of the pupils for example believed that experiments were able to unveil the truth about nature and that scientific experiments are able to prove a theory. In addition to this, some participants also showed an inconsistent answering behavior concerning some parts of the topic. The pupils were, on the one hand, aware of the fact that even in scientific experiments measurement errors could occur, but they, on the other hand, also thought that one could avoid measurement errors if one only measured accurately enough.

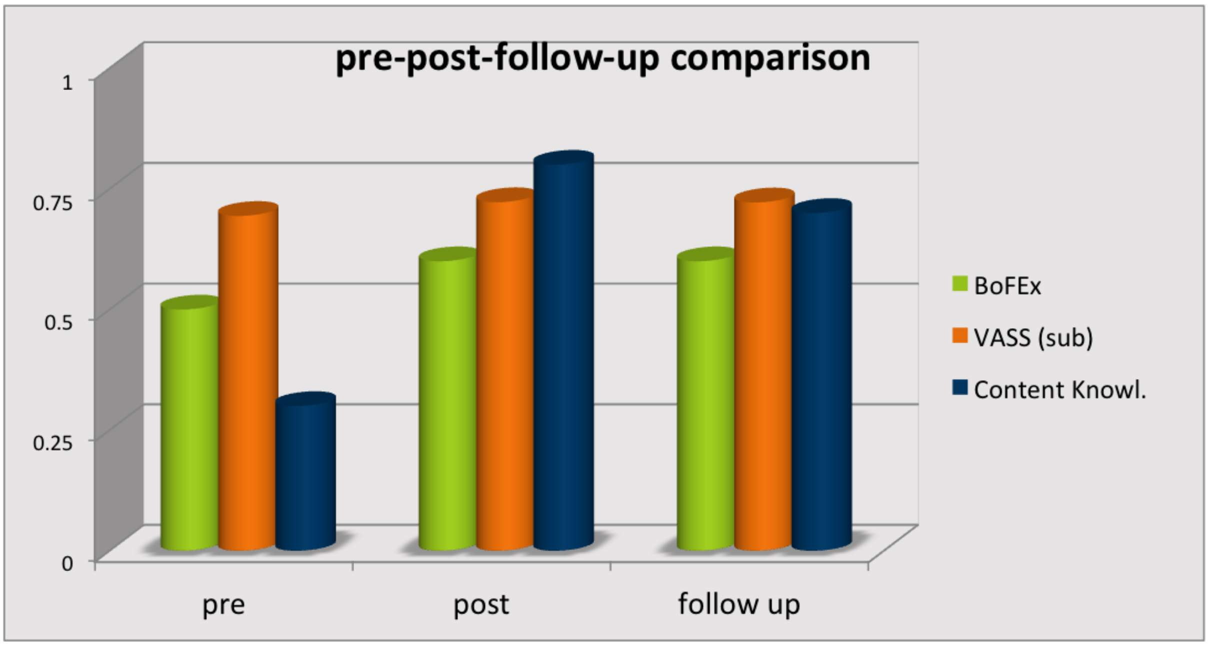

Figure 2: Results of a pre-post-follow-up comparison (BoFEx: views about experiments; VASS: Views about Science Survey; Content Knowl: Content Knowledge Test about Plasma Physics)

B) The comparison of the sum-scores revealed the following results: On the one hand, there is a significant change between the pre- and the post-test concerning the BoFEx as well as the VASS-test. On the other hand, the difference between the post- and the follow-up-test, in both the BoFEx and the VASS, is not significant (see fig. 2).
Hence, the results show that it is possible to change pupils' views about experiments in relatively short interventions.
At the same time, the students significantly increased their knowledge in physics (fig. 2). Even though the drop between post- and follow-up is significant, students in the long run leave the project with a higher level of physics knowledge in comparison to the beginning of the instruction.

CONCLUSION AND IMPLICATION

The results show that students' views about experiments are in some aspects inadequate. Hence, there is a need to develop instructions that teach adequate views of the very basic method of scientific work. The project at hand shows one way. Another aim of the presented approach was showing that it is possible to change pupils' views about the NoS concerning a special focus (beliefs about the "nature of experiments") in a one-day project. In our opinion, a relatively small NoS focus, authentic aspects, reflexive discussions and the integration of both, physics and NoS, are very important. We also believe that different NoS aspects require different methods. Therefore, the interviews with scientists and the guided laboratory tours, which are part of this project, are not a necessary prerequisite of teaching other NoS topics. One could also try, for example, to achieve authenticity by using (historical) original sources such as articles or videos of physicists. This is especially important for schools lacking the possibility of visiting scientific research facilities. The project is meant as a first step. Next steps will be transferring this attempt to instructions in schools by developing more projects with different NoS-aspects and evaluating the efficiency of authentic, explicit, reflexive and well-dimensioned NoS-projects at schools. From our point of view, making different NoS-aspects a frequent explicit topic of discussion can lead to more adequate epistemological beliefs in the long run.

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STUDENTS IDEAS ABOUT DIAGRAMS OF A FLOWER AND A PLANT CELL

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Abstract: In this study, primary school students ideas about flower and plant cell in the method of drawing in combination with interviews are examined. The data gathered from 40 students from UK and 16 students from Turkey in year 7. Semi-structured interviews were carried out with 5 students. The students for interview were randomly selected from the total sample. The data was collected in three steps. First the students were asked to draw diagrams of a flower and a plant cell and to Show the parts of them by using labels. In second step a survey consisting of 10 open-ended questions was prepared and given to the students. In the third step, semi-structured interviews were carried out in order to examine the thoughts of the students on this subject more thoroughly. Each students interview lasted for approximately
30 minutes. The data was collected in the school year 2009-2010. Data was treated by qualitative data analyisis method- open coding. The data obtained from the survey and interviews were categorized and arranged based on the alternative ideas of the students. In our study we found that they were simply copying internet diagrams or book diagrams instead of drawing their own diagrams.

Keywords: Diagram, science, flower, plant cell.

INTRODUCTION

Generally pictures and diagrams constitute a very effective, plentiful, and inexpensive teaching medium. Although many studies demonstrate large learning gains when instruction includes diagrams (e.g. Mayer and Anderson, 1992; Mayer, Moreno, Boire, and Vagge, 1999), using diagrams does not always lead to improved outcomes. Relevance may be difficult to determine prior to assessment (Davenport, Klahr and Koedinger, 2007). Pictures have enormous potential as teaching tools. However, they have to be carefully selected and professionally utilized.

Where drawings have been used to probe understanding in science, they have been used in a variety of ways. In a previous study (McNair and Stein, 2001), fifth, eighth and eleventh grade students were asked to draw a plant and include plant parts, functions and information about what plants need to grow in their drawing. Reiss and Tunnicliffe (2001), Reiss, Tunnicliffe and Andersen (2002), and Prokop and Fancovicová (2006) used children's drawings to provide a reliable indication of what children know about the human body (as cited in Köse, 2008, p. 283). Tunnicliffe and Reiss (2000) have conducted studies that investigated children's conceptions about plants. They conducted interviews with 36 children, ages 9-14, recording their comments and reasoning. The results indicated that, as children age, their reasons for grouping plants become more complex: in addition to relying on shared anatomical and habitat features, they begin to show evidence of a knowledge of taxonomy and use this knowledge to group plants (as cited in Goins, 2004, p. 2).

In this study, students' ideas about flowers and plant cells using the method of drawing in combination with interviews are examined.

METHODS

Design of the Research

A qualitative approach was adopted. The interviews were semi-structured.

Universe and Sampling

The data was gathered from 40 students from UK and 16 students from Turkey, all in year 7. The research was performed in Reading (UK) and Sakarya (Turkey). Semi-structured interviews were carried out with 5 students. The students were randomly selected from the total sample.

Instrumentation and Analysis

The data was collected in three steps. Firstly, the students were asked to draw diagrams of a typical flower and a typical plant cell and to show the parts of them by using labels. In the second step, a survey instrument consisting of 10 open-ended questions was given to the students. In the third step, semi-structured interviews were carried out. The data was collected in the school year 2009-2010. The data was treated by qualitative data analysis (open coding) (Bryman and Burgess, 2004).

RESULTS

All the students drew a simple flower, not a complex flower such as a daisy. This indicated that the students may not know the identity of the flower that they drew.

The Open-Ended Questions

Question 1. Which flower do you believe you drew?
The daisy was found to be the main flower they believed they drew.
Question 2. Do you think all the flowers have same scientific section? Please explain
24/40 students from UK and 13/16 students from Turkey mentioned that all the flowers have the same scientific section. None of them could explain this.
Question 3. Is there any other scientific section of a flower that you know about? Please give an example and explain what the differences are.
Most of the students mentioned that they did not know any other scientific diagram.
Question 4. Why did you choose to draw this scientific diagram?
For the students, 'I like it' was found to be the main reason (12) for choosing to draw these diagrams.
Question 5. Please draw a scientific diagram of a daisy.
All of the students from UK and Turkey tried to draw a diagram of a daisy but all of them were incorrect.
Question 6. Which kind of plant cell did you draw?

The palisade cell was found to be the most common answer of the students from UK (11/40).
The tulip cell was found the most common answer of the students from Turkey (8/16).
Question 8. Do you think all the plant cells are same? What other kinds do you know?
Half of the students said that all plant cells are same. The other half who wrote that all plants cells were not same could not explain it correctly.
Question 9. Why did you choose to draw this plant cell?
The most mentioned reason was that, "it was the only one I know" (14).
Question 10. Is the cell in Fig. 1 plant cell or an animal cell? Why do you think so?
Please show the parts of this cell by using labels.

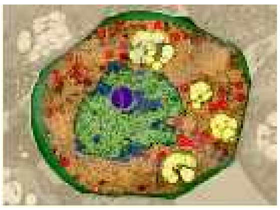
Figure 1. Image of a cell accompanying open-ended question no. 10

17/40 students from UK and 13/16 students from Turkey mentioned that the cell was an animal cell. Most said that it was because it is round.

The Interview

All the students interviewed (5) thought that all flowers have the same scientific diagrams and they did not know about complex flowers. They thought that all plant cells were same. They did not know any other plant cell diagram. Also all of them mentioned that the illustrated cell was an animal cell because it was circular.

DISCUSSION

There are many surveys that show that students who used integrated (diagram-based with text) explanations are better able to understand concepts (e.g. Butcher, 2006; Davenport et. al., 2007). In our study we found that the students could not draw diagrams, they can only copy them from those given. We saw that most of the students interpreted visuals as the same and also wrongly that is, they probably did not know how to read the diagrams.

Although diagrams are considered as effective personal tools for solving problems, applied research in education has identified diagrams are a widespread problem: and that students lack spontaneity in diagram use (Uesaka and Manalo, 2007). Most of the biology books include more words than diagrams. So, it may be that the teachers and students try to learn biology subjects mainly from the text, not from the diagrams. In addition, in examinations the students are asked to use diagrams instead of making diagams, for example they are asked to label diagrams. So this makes students focus on given diagrams.

IMPLICATIONS

Whether diagram-making or diagram interpretation should be part of the science curriculum is an important issue. This is the usual tension of learning basic facts (a low level content rich curriculum that is very traditional) or of learning scientific procedures, such as diagrammaking and interpretation. This matter needs to be explored among science educators and policy makers, as a development of this research.

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USING KITCHEN STORIES AS STARTING POINT FOR CHEMICAL INSTRUCTION IN HIGH SCHOOL

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Abstract: New approaches to chemical instruction are needed. High-school students do not find chemistry and chemistry education interesting, and there is a correlation between attitude and learning results. Therefore, novel approaches to chemistry instruction that the student can relate to need to be designed. Molecular gastronomy and so-called kitchen stories are one possible context to be used as the starting point for chemical instruction. This study is part of a larger design research, the aim of which is to study the use of kitchen stories in context-based chemistry teaching. The purpose of this case study is to find out how kitchen stories can be used as the starting point for chemical instruction on high school level, taking the aims of Finnish National Curriculum into consideration. The studied kitchen stories were collected from high school students by 20 teachers, who participate in 3-year in-service training Molecular Gastronomy in Chemistry Teaching. The stories were analysed by grounded content analysis. Four groups emerged from the data: (1) Proverbs and folktales, (2) Methods and ingredients in cooking, (3) Nutrition and health, and (4) Cleaning and restoring. Group number 2 is relevant for the present study. The central chemistry contents were identified according to Finnish National Curriculum, and the stories in group number 2 were classified according to these contents. Out of the twenty-two contents from the curriculum, six can be covered with kitchen stories. On the second phase of the design research, teaching models based on kitchen stories will be developed to cover these contents in chemistry instruction. Also the effects on students, when using kitchen stories as the starting point, will be studied.

Keywords: Kitchen stories, curriculum, chemical instruction

BACKGROUND

On a global scale, the youth see the importance of natural sciences to the society, but do not consider these subjects important on a personal level. In addition, the level of interest towards studying natural sciences is low (OECD, 2010). Finding the answer for the lack of interest is one of the biggest challenges in science education today (Lavonen et. *al*, 2009). The lack of interest and too few applicants to science education is a challenge also in Finland. Finnish high-school students are among the highest performing in science in the OECD countries (OECD, 2010). However, Finnish high school students' attitudes towards science are more negative than in any other OECD country (Hautamäki et. *al*, 2007). The interest is particularly low towards chemical phenomena (Lavonen et *al*. 2005). There is a demand for new meaningful approaches and perspectives for chemical instruction.

There are many challenges in chemistry education. One of those is the lack of relevance. In their everyday life students do not see any reason why they should learn chemistry, and where the knowledge in chemistry is needed. By approaching chemical facts and phenomena through meaningful concepts from everyday life, some challenges in chemical education can be addressed (Gilbert, 2006). Context-based approach to chemistry education is one way to look at chemistry using concepts and applications as starting points for the development of scientific ideas (Bennet et *al*., 2006).

Based on many previous studies, context-based approach to learning can be used to improve the students' interest and attitude towards chemistry education (Pilot & Boulte, 2006). However, there is relatively little evidence that context-based learning could improve learning results (Bennett, 2005). According to a research by Jager and Weld (1999), there are significant differences in learning results between context- and concept-based learning. According to Gilbert (2011), learning can be enhanced if the learner is interested in the context and sees the significance of the learning experience.

There are six features that should be present in high-quality chemistry education: 1) the conceptual structure of chemistry, 2) the process of chemistry, 3) the technological manifestations of chemistry, 4) chemistry as a "personally relevant" subject, 5) the cultural aspects of chemistry, 6) the societal implications of chemistry (Kempa, 1983). By using molecular gastronomy and kitchen stories as the starting point for context-based teaching of chemical concepts, all these features can be included in a way that interests the student through every-day experience (Västinsalo & Aksela, 2010).

MOLECULAR GASTRONOMY AND KITCHEN STORIES

Molecular gastronomy is a relatively new scientific activity, looking for mechanisms of phenomena occurring during cooking and in culinary transformations (This, 2009). One perspective to molecular gastronomy is to observe and analyse scientifically the so-called kitchen stories. Kitchen stories refer to culinary advice that has been passed along from generation to generation of chefs, mothers, and cookbooks. Over 20,000 kitchen stories have been collected from French cookbooks. In molecular gastronomy the scientific study of kitchen stories is one key element (This, 2005). Thus, kitchen stories may function as a fertile starting point for chemistry education. The stories can be regarded as scientific claims with more or less open inquiry.

OBJECTIVES

This study is part of a larger design-research (Edelson, 2002), the aim of which is study how to approach chemical education through kitchen stories from many perspectives. The most important perspectives include: 1) learning chemical concepts through kitchen stories, 2) developing the students' argumentation skills, 3) developing the students' thinking through kitchen stories and inquiry-based learning, 4) supporting the students' interest towards chemistry by context-based approach to kitchen stories, 5) developing practical teaching models that the teachers participating in the 3-year in-service training use with their students.

Design research is a cyclical process, in which design and research are done during theoretical and empirical phases. Design research can be divided into three phases: 1) problem analysis, 2) design process, and 3) design solution. These phases are cyclical and repeated several times (Edelson, 2002).

This design research is conducted during the three years while Molecular Gastronomy for Chemistry Teaching in-service training for chemistry and home economics teachers is being developed. 20 teachers from 10 schools, one chemistry and one home economics teacher from each school, participate in the training. The training includes 12 2-day sessions, and new approaches to chemical concepts through kitchen stories are being developed for each session. In between the sessions, the teachers test the new approaches in practice and revise them according to the educational needs of their students. The teachers report their experiences and practices systematically. The reports are being used in the evaluation and development of the process.

Molecular Gastronomy in Chemistry Teaching in-service training has been designed to fulfil the requirements of context-based learning: setting of focal events, behavioural environment, specific language, and extra-situational background knowledge (Gilbert et al, 2011). The teachers' active role in the development of context-based teaching model is important. They need to be provided with materials and pedagogical interventions, so that the context can be implemented in the teaching (Hofstein & Kesner, 2006).

This case study is part of the problem analysis of the larger design research, the aim of which is to pin down the needs and define the goals of the design research.

OBJECTIVES OF THIS PROBLEM ANALYSIS CASE-STUDY

The aim is to map, how chemistry education can be approached through kitchen stories, taking the aims of National Curriculum into consideration (OPH, 2004). In a previous problem analysis case study, the students' needs for new approaches to chemical instruction were studied and the students' interest towards the context of molecular gastronomy in education was scrutinised (Västinsalo & Aksela, 2010).

This research was guided by question:

1. From the perspective of Finnish National Curriculum, how can kitchen stories be used as the starting point for chemical instruction at high school level?

METHODS

The research data was gathered by in-service teachers, who had enrolled for Molecular Gastronomy in Chemistry Teaching training, before the first session. The in-service teachers were asked to gather kitchen stories from high school students. The concept of kitchen story was clarified to the teachers through written examples and they were asked to explain the concept to their students as well before gathering the stories.

All the kitchen stories that the teachers gathered were included in the research data. After the similar stories had been erased from the data, there were altogether 126 different stories. The stories were analysed by content analysis, and classified according to grounded theory (Cohen et al., 2009). Four different classes emerged from the data. The classes were formed as follows: All stories that included word play (rhymes etc.) or were clearly proverbs were tagged with number 1. For example kitchen story "cold coffee makes you beautiful" is a Finnish proverb. The stories that included some kind of an advice or instruction for cooking were tagged with number 2. For example story “Kiwi fruit prevents gelatine from gelling” was tagged with number 2. Number 3 was used to mark all stories that gave advice on how to benefit health or beauty with food. For example, story “blueberries improve eyesight” was tagged with number 3. All stories that included advice to use food ingredients in cleaning, instructions on how to take care of cooking instruments, or advice on how to restore food were tagged with number 4. For example, stories “do not wash cast iron pan with dish soap” and “never freeze once frozen food again” were tagged with number 4.

The classes that rose from the data were named accordingly: (1) Proverbs and folktales, (2) Methods and ingredients in cooking, (3) Nutrition and health, and (4) Cleaning and restoring. From these classes, number 2 is relevant for the present study.

In the next phase, the central chemical contents were identified from the Finnish National Curriculum. The number of different contents was 22. The kitchen stories from class 2 (Methods and ingredients in cooking) were categorised under these contents.

The main chemical phenomenon of each story was defined in the story. For example, “you cannot boil eggs on top of Mount Everest (boiling point of water)”. After the main chemical phenomenon of all stories from class 2 had been defined, the phenomena was categorised according to chemical contents in the National Curriculum. In this case, the boiling point is a property of water and belongs to category: Water and its properties. A second example: “Eggs stored in room temperature whip better (denaturation of proteins)” was categorised under Proteins.

To improve the reliability of classification, it was done several times by the researcher. Also another researcher did the classification and a kappa value was counted to measure of inter-rater agreement (Brennan & Prediger 1981).

RESULTS

The group Methods and ingredients in cooking (n=65) was divided further into classes that rose from the Finnish National Curriculum (OPH, 2004). All chemical contents from the chemistry curriculum for high school were collected. There were 22 main contents. The kitchen stories were classified according to the curriculum contents by the main chemical phenomenon that occurs in the story. Examples of stories are in table 1. The measured inter-rater agreement was 90%. Free marginal kappa value (Randolph, 2005) was 0,88.

Table 1 Examples of kitchen stories

Chemical content from curriculum	Example of kitchen story	n=
Carbohydrates	“Brown sugar will soften, if you place a piece of dark bread next to it.”	11
Atmospheric substances	“If you want to leaven a cake with yeast, set it in a warm place.” ”If you use soda in baking, add buttermilk.”	6
Lipids	“If you want low-fat soup, you can absorb fat from the surface with an ice cube.” “If you add oil in cooking water, pasta won’t get entangled.”	6
Oxidation of organic compounds	“Wine will not ferment in a dirty bowl.” “Dip pieces of apple in orange juice and they won’t get brown in salad.”	4
Proteins	“Eggs will not foam, if they are fresh.” ”Salt in soup will make the meat cook slower.”	24
Water and its properties	“Add salt to boiling water, the potatoes will cook faster.” “You can prevent the ingredient from going sour by adding baking soda.”	14

CONCLUSIONS

From the perspective of Finnish National Curriculum, kitchen stories are a possible way of approaching chemical concepts in teaching. There are six themes out of 22 in the Finnish Curriculum in which kitchen stories can be utilized: Water and its properties, Atmospheric substances, Oxidation of organic compounds, Carbohydrates, Proteins, and Lipids. In France, molecular gastronomy has already been used to cover contents of the curriculum at comprehensive school level (This, 2005). The kitchen stories can be handled as scientific claims.

In previous studies on context-based learning, there has been a need to alter the contents in the curriculum (Millar & Osborne, 2000). Based on the results from this study, there is no need to change the contents of curriculum to use molecular gastronomy and kitchen stories in chemistry teaching as the method can be easily integrated into the existing curricula.

Teaching models based on kitchen stories will be developed in the design research according to this problem analysis. These models will include contents that increase the students’ interest and methods that the students’ themselves wish would be more frequently used in instruction. The models will include reading literature, laboratory work with traditional and modern equipment, ICT-based learning, sensory experiments, and social, student-centred methods (Lavonen et *al*, 2005; Juuti et *al*, 2009).

The results from the previous problem analysis of this design research show that the students are interested in the kitchen story approach (Västinsalo & Aksela, 2010). There is a correlation between attitude and learning results: Those who have a positive attitude towards chemistry get better results (Salta & Tzougraki, 2004, Freedman, 1997). However, there is only little research evidence on whether context-based learning can improve learning results (Bennett, 2005). According to this problem analysis case study, the following goals can be set for the design research:

- Developing teaching models based on kitchen stories that cover the following chemical contents in the Finnish National Curriculum: Water and its properties, Gases, Oxidation of organic compounds, Carbohydrates, Proteins, and Lipids
- Studying the functionality of the developed teaching models through the teachers participating in Molecular Gastronomy in Chemistry Teaching in-service training and developing the models further.
- Studying the effects of these teaching models on concept learning as well as argumentation and thinking skills in students.
- Gathering more kitchen stories and studying how they can be used in teaching of chemical concepts.

The next case study will be to research concept learning, argumentation and thinking skills among high school students in the context of kitchen stories.

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THE USE OF THOUGHT EXPERIMENTS IN TEACHING PHYSICS. THE CASE OF THE PRINCIPLE OF EQUIVALENCE

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Abstract: In this work an attempt is made to explore the possible value of using thought experiments in teaching physics to upper secondary education students. Specifically, a qualitative study is designed to investigate the extent to which the thought experiment "Einstein's elevator", by drawing material from books that popularise physics theories, can function as a tool in teaching the "principle of equivalence". It was shown that the teacher of physics by using this thought experiment may help students mentally arrive at situations that considerably exceed their everyday experience. In this way, students are able to approach physics theories with a high level of abstraction. Students after the experimental implementation were able to formulate the "principle of equivalence", explain phenomena based on this principle and also explain the deflection of light in gravitational fields as a consequence of this principle.

Keywords: Thought Experiments, Secondary Education, Principle of Equivalence

BACKGROUND, FRAMEWORK, PURPOSE, AND RATIONALE

In science, apart from real experiments, thought experiments (TEs) are extensively used (Mach 1896/1976). TEs are experiments that are "performed in the laboratory of the mind" and distinguished scientists such us Galileo, Newton, Einstein and Heisenberg used TEs in their works (Brown 1991, Sorensen 1992). Also, a number of philosophers of science (e.g. Mach 1896/1976, Kuhn 1977, and Popper 1959/1999) have analyzed the role of TEs in science.

TEs, besides the significant role they play in physics, could be proved important educational tools too. Indeed, TEs are an integral part of physics textbooks, whose authors use TEs in order to present physics theories to students (Velentzas et al. 2007). Also, the use of TEs in the classroom motivates students to use their imagination, develop their critical thinking, make hypotheses and infer outcomes (Matthews 1994, Reiner & Gilbert 2000). In addition, teachers consider that TEs are important tools in teaching physics laws with abstract and concise formulations (e.g. theory of relativity), because they feel that TEs help in bridging the gap between students' experience and the concepts to be taught (Helm et al. 1985).

On the other hand, well known scientists (e.g. Einstein, Gamow, and Landau) used TEs in order to communicate physics theories to the public. They wrote books that popularise physics theories wherein a lot of TEs can be found, especially when the authors present physics theories of the 20th century (Velentzas et. al. 2007). The code of science popularization (which is a non formal science code) appears to be very appealing to students (Halkia & Mantzouridis 2005).

In the present work an attempt is made to explore the possible value of using TEs in teaching physics to upper secondary education students. Specifically, a qualitative study is designed to investigate the extent to which the TE "Einstein's elevator", by drawing material from books that popularise physics theories, can function as a tool in teaching the "principle of equivalence". Especially, the research question of this study is: To what extent does the use of the TE "Einstein's Elevator" may help students formulate the "principle of equivalence", explain phenomena based on this principle and explain the deflection of light in the gravitational fields as a consequence of the principle.

METHODS

The TE known as "Einstein's elevator" was selected, in a popularized form as it was found in Einstein's two books (Einstein 1961, Einstein & Infeld 1938). The study of the relevant literature was used to design a lesson plan. A pilot study took place in a sample of 8 students divided in two groups. This study helped us to detect students' difficulties and weaknesses of the lesson plan and design the final form of it.

The lesson plan was carried out through semi-structured interviews. The teacher acted both as an interviewer and as teacher, according to the "teaching experiment" method (Komorek & Duit 2004). The teacher was responsible for supporting the interaction among the students and he intervened when the student-student interaction was no longer fruitful.

The sample of the research consisted of 40 upper secondary school students (aged 16, grade 11) from 6 different schools in the area of Athens. The students were divided into 11 groups of 3-4 students each. The experimental implementation lasted 2 hours for each group of students.

The data were collected by taping and transcribing the interviews, and by distributing a questionnaire to students 15 days later. This questionnaire included open-ended questions. Methods of qualitative research were applied to analyse the data (Erickson 1998).

THE TEACHING / INTERVIEW PLAN

1st step: Students, discussing their experience in a vertically accelerating booth, (e.g. in an amusement park), reach the conclusion that the upward (or downward) acceleration "adds" (or "subtracts") an amount of gravity. Then, they create in their mind an environment with "weightless conditions" inside a booth which is in a free fall.

2nd step: Students, imagining a uniformly accelerating booth out of any gravitational field (GF), develop relevant syllogisms and reach the conclusion that phenomena occurring in the accelerating booth are the same as if the booth were motionless in a homogeneous GF. Then, with the help of Einstein's relevant text they generalize the results and formulate the "principle of equivalence".

3rd step: Students apply the "principle of equivalence" when a spaceship is accelerated out of any field of gravity to different directions and they discuss the meaning of what is "upward" or "downward".

4th step: Students taking into consideration the "principle of equivalence" and imagining a light beam inside the accelerating booth are led to conclude that a beam of light is deflected by the action of a GF. They apply this in the case of a light beam passing near the Sun.

FINDINGS - RESULTS

(i) Students managed (starting from their own experience with gradual abstractions) to mentally arrive at situations that do not take place in everyday life.

Specifically, discussion motivated by students' experience of fast elevators or amusement parks played a significant role in the development of the TE. All students described or agreed in describing an experience that the upward acceleration is as if "it adds an amount of gravity" whereas the downward acceleration is as if "it subtracts an amount of gravity" and finally they arrived at the conclusion that inside a booth which falls freely "it is as if there were no gravity". Then, by using the TE students reached the conclusion that the acceleration outside a GF "imitates gravity". As a matter of fact, most students (32/40) mentally eliminated the effect of the GF in the space of an accelerating booth and were able to predict that a man inside the booth "can stand upright". The rest of the students (8/40), at first, were hesitant or claimed that the man "suspends", but they overcame this difficulty with the help of their classmates who basically argued that "the man is outside the GF and because of the inertia he tends to move with a constant velocity and therefore the floor of the accelerating booth pushes him". After that, all students were able to predict the "fall" of the objects in the booth with the same acceleration. At the end of the process students claimed that the passenger of the booth in the TE "feels as if the booth is stationary on the Earth".

(ii) The process of performing the TE and then the reading of Einstein's corresponding text seemed to have helped students so that they may formulate in their own words the "principle of equivalence" (e.g. "instead of considering an accelerating booth outside a GF, you can consider it stationary within a GF").

However, it is worth noting that approximately half of the students, while they predicted correctly the phenomena in an accelerated system outside a GF, yet for the explanation they did not use the term "principle of equivalence". These students preferred to describe the phenomena according to the inertial observer; a fact which relates to their persisting idea that only the external observer knows the "absolute truth".

(iii) While students' everyday experience may play a positive role in the "performance" of a TE, it may however be an obstacle when the consequences of a TE considerably exceed the experience of students.

Indeed, whereas in the beginning the experience in the amusement park seemed to play a beneficial role in the development of the TE, later on, in one of the applications where the result was in obvious opposition to the everyday experience (a drawing where a spaceship accelerated "horizontally") seemed to be an obstacle for a number of students. This obstacle was overcome through the discussion and finally they arrived at the conclusion that the meaning of "upward – downward" relates to the direction of the equivalent GF.

(iv) Students by using the TE reached the conclusion that the light is deflected by the action of a GF as a consequence of the "principle of equivalence".

All students claimed during the "performance" of the TE that the light beam is deflected to a direction opposite to the acceleration. However, there was a difficulty for many students (25/40) to explain the shape (curve) of the "path" of light, but they understood it once it was explained by their classmates or by their teacher. Then, students in their discussion to respond to a relevant question decided that the passenger of the booth will ascribe the deflection of light beam to the action of a GF. Also, students were in a position to apply qualitatively (with the appropriate drawing) the above conclusion to beams of light which pass quite near the Sun.

CONCLUSIONS AND IMPLICATIONS

In the present work an attempt is made to use a TE as a didactical tool for teaching physics. It resulted, that this TE, as it is presented in Einstein's books "popularizing" physics, may constitute useful educational material for designing lesson plans to teach the "principle of equivalence". This is due to the fact that in the TE there is the element of narration and the handling of lesser mathematical formalism so that students may easily follow the lesson plan with interest focusing on the meaning of concepts. This facilitates the process of a basic understanding, something which must be the aim of teaching physics in secondary education.

It was shown that the teacher of physics by using this TE may help students mentally arrive at situations that considerably exceed their everyday experience. In this way students are able to approach physics theories with a high level of abstraction. Students after the experimental implementation were able to formulate the "principle of equivalence", explain phenomena based on this principle and also explain the "deflection of light in gravitational fields" as a consequence of the principle.

In conclusion, the results of the present work, as well as of the other research (Velentzas & Halkia 2010, Reiner & Burko 2003, Gilbert & Reiner 2000), support the view that TEs constitute important didactic tools for students of upper secondary education in learning principles and laws of physics with a high level of abstraction.

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THE EFFECT OF LESSON DURATION (45 VS. 60 MINUTES) ON QUALITY OF PHYSICS INSTRUCTION

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Abstract: Although there is no theoretical framework and hardly any empirical investigation on optimal lesson duration, several German upper level secondary schools currently prolong lesson dura- tion from 45 minutes to 60 minutes in order to improve instructional quality. This study inves- tigates this assumed impact of lesson duration for the case of physics instruction. Therefore 60-minute-lessons of four physics teachers are videotaped and analyzed in comparison with 45-minute-lessons of the same physics teachers from a previous study. Video analysis follows the theory of basis models of teaching and learning by Oser (2001). A pupil questionnaire and an expert instructional quality rating accompany the video analysis. This study wants to deliv- er first hints whether the change in lesson duration alone impacts instructional quality or whether additional professional development is needed to make efficient use of the prolonged lessons.

Keywords: Lesson duration, learning processes, basis models, physics instruction

BACKGROUND AND AIMS

The origin of lesson durations is widely based on tradition and pedagogical intuition rather than on learning theories or empirical investigations. In Germany, the lesson duration was changed from 60 down to 45 minutes in the nineteenth century to allow pupils to help in agri- culture in the afternoons (Fölling-Albers, 2008). Although this justification is clearly outdated today, schools continue in this tradition. Other European countries like Switzerland or Finland have similar lesson durations, with physics and sciences in general often taught as “double- lessons” (2x45 minutes). Outside of Europe exist slightly longer lessons in the case of South Korea (50 minutes) or Canada, where lesson duration may vary from school to school. Al- though some work has been done on “learn time” in the broadest sense (see Carroll (1964), Walberg, (1986), Aufschnaiter (2003), Seidel & Shavelson (2007)), at present there is no theoretical or empirical work concerning the optimal duration of lessons.

Recent attempts in Germany to improve instructional quality have let several schools intui- tively decide on 60-minute lessons. This change, again, is not based on learning theories and has not been investigated empirically, yet. It is therefore especially timely now to start inves- tigating the effect of lesson duration on quality of instruction.

Making use of the current transforming situation in some German schools, we formulate the following research aim: Does the recent prolongation of physics lesson duration from 45 up to 60 minutes have an effect on instructional quality? The answer to this question may deliver hints towards the optimal physics/science lesson duration for all European countries.

DESIGN AND METHODS

This study builds on the knowledge base of Wackermann et al. (2010). It makes use of the fact that Wackermann et al. (2010) conducted a professional development program for physics teachers four years ago. The study involved videotaping and was carried out under the condition of traditional 45-minute lessons. By chance, four of the former participating teachers today teach under the condition of 60-minute lessons. Instruments of the former study are applicable to investigate instructional quality and will be used again in this study.

The sample consists of four physics teachers from two German secondary schools that recently changed the lesson duration from 45 to 60 minutes. Each teacher (and one of their classes, 8^{th} to 10^{th} grade, respectively) is videotaped four to five times under both conditions. The teachers were/are asked to present lessons where they introduce something new. Videos were/are taken according to the guidelines of the TIMS-video study (Stigler & Fernandez, 1995). In addition, pupils were/are administered a very short questionnaire right after each videotaped lesson.

Variables under investigation include *basis model orientation* (video analysis), pupils' *ability to follow instruction* (pupils' questionnaire) and certain aspects of instructional quality such as *clarity* or *pacing* (expert's view, video analysis). Basis model video analysis investigates in time-slots of 1 minute whereas the expert rating and the student questionnaire cover the whole lesson. The full set of variables and instruments is listed and explained in Wackermann et al. (2010).

Instrument	Variables	Origin
Basis model video analysis	*Basis model*, *Instructional phase*, Level of implementation (each separate for teachers and pupils)	Oser (2001); Wackermann et al. (2010)
Instructional quality rating	*Clarity and structuredness*, *Cognitive activation*, *Pacin*g (and more variables)	Clausen (2002)
Short pupils' questionnaire	*„I was able to follow the instruction today* "	Wackermann (2010)

The study follows an experimental design with pre- and post-measurement. Pre-videos were taken four years ago (see Wackermann et al., 2010) and post-videos are taken beginning in fall 2010 when lesson duration had been prolonged to 60-minutes for about two years.

Data acquisition is halfway complete and analyses have started. Two of the four teachers have been videotaped four times each under the new condition. For both research questions the planned statistical analyses include $\chi 2$-tests for categorical variables and t-tests for continuous variables, respectively.

One hypothesis concerns the duration of the last instructional phase of a learning process, which deals with important aspects like decontextualization or content linkage. The analysis of 80 videos of 18 different physics teachers (see Wackermann et al., 2010) under the condition 45 minutes showed that not even 3 % of lesson time were spent on this last phase of a learning process. The finding was astounding, since teachers received coaching with respect to organization of learning processes. Since mostly only the last phase of a learning process was missing, a modest prolongation of lesson duration may facilitate completion of learning processes (Borowski, Fischer, Trendel & Wackermann, 2010).

FINDINGS

The basis model video analysis has been carried out for the two teachers and statistical tests for difference show no significant change in *basis model orientation* from 45 to 60 minutes. At this point in the analysis, neither the use of basis models nor the completeness of basis models nor the average level of implementation have altered. Learning processes were not significantly more often complete under the new teaching condition. However, those instructional phases that were carried out appear significantly longer (significant mid-sized effect) under the new condition.

Also at this point in the analysis, the pupils' view on their ability to follow the instruction shows no significant difference between the two teaching conditions. The pupils on average find it rather easy to follow the instruction with natural significant differences within the classes (especially high- vs. low-performer).

The expert instructional quality rating is currently performed. A first glimpse also seems to indicate no significant change in general aspects of instructional quality such as pacing or clarity.

CONCLUSIONS AND IMPLICATIONS

Surprisingly, so far learning processes did not get completed as expected (see hypothesis in Design section). Instead, the first instructional phases appear to be simply prolonged and the teachers fill the whole lesson with much the same content as before. It is therefore not surprising that pupils on average find it rather easy to follow the instruction (although this was already the case for the pre-videos). In conclusion, the two teachers so far investigated seem not, at least not as expected, to make use of the prolonged lessons.

The analyses concerning the effect of lesson duration on general aspects of instructional quality, currently underway, seem to support no significant change in the instruction. Simply altering the outer conditions does not seem to alter teaching behavior. As a result, additional professional development for the teachers seems to be necessary to make efficient use of such prolonged lessons.

This study, especially in view of the sample size, obviously does not allow any kind of generalization. However, it may offer implications as to where future research could point to, possibly extending to other subjects, "double-lessons" or professional development programs. Videotaping of the other two teachers is currently foreseen for fall 2011 with final results being available in spring 2012.

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RESEARCHING EXPERIMENTAL PHASES IN CHEMISTRY EDUCATION USING VIDEO ANALYSIS

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Abstract: This study focuses on experimentation as a subject-specific operation in chemistry education. Laboratory experiences are said to enhance the students' learning achievement, interest, and motivation. In this paper a study dealing with the effectiveness of different quality criteria of experimental work in classroom situations is described. The study consists of two parts, an observational and a quasi-experimental part. In the first part experiment-specific quality criteria and their influence on interest, motivation and learning outcome are observed in regular chemistry lessons. In the second part teachers are trained based on these categories (e.g. post-processing of the experiment, instructional efficiency, problem-solving) in order to enhance interest, motivation and learning outcome in their classes. Results of this study offer practical implications to enhance the quality of experimentation phases in chemistry lessons.

Keywords: quality, experiments, chemistry education, video analysis

THEORETICAL BACKGROUND

General quality of instruction is defined "*as a bundle of characteristics describing instruction (process quality) which have a positive effect on teaching outcomes (product quality)*" (Einsiedler, 2002). Thus, 'good instruction' can be defined as something from which we can measure positive effects concerning the students´ performance. Reusser and Pauli (2003) describe the quality of instruction in a systemic model (fig. 1).

The systemic model of quality in education is divided into three levels: the system; the school and family; and the class and individuals. All of these levels are subdivided into the quality of learning opportunity and the quality of using the offer, so they all interact.

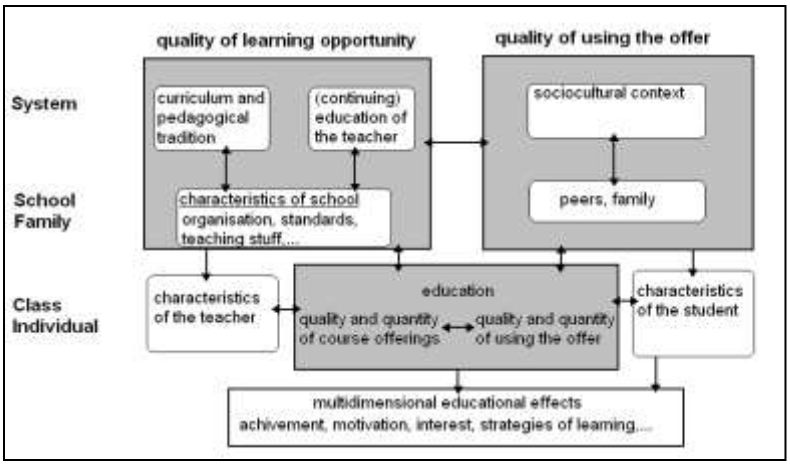

Figure 1: Systemic model of quality in education (Reusser & Pauli, 2003)

Helmke (2003) describes factors of quality in education in an "offer and use model" (fig. 2). In this model, education is deemed to be an offer, whose effectiveness depends on the teacher, the context and the activity of learning (the use). In turn, the use depends on many mediators like the family, the achievement potential and the context.

In this project, we will look at the class/individual level and within this level at the education, the characteristics of the students and the effects of instruction (output).

Most characteristics of instructional quality are for general instruction. Helmke (2002) and Ditton (2000) state that it is "out of date" to look only at the general quality of instruction, so they call for specific characteristics of quality in specific subjects. Rakoczy & Pauli (2006) speak about the "need of subject and domain specific processes to measure subject specific quality in education".

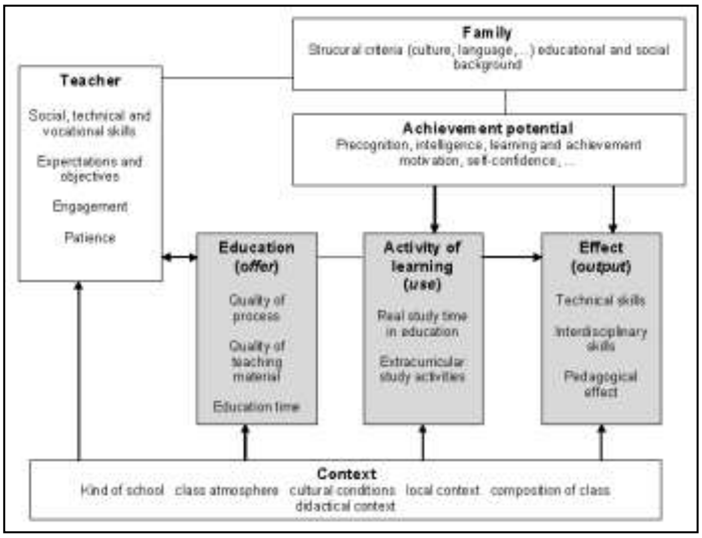

Figure 2: Offer and use model (Helmke, 2003)

Experimentation has a central and distinctive role in chemistry instruction (Hofstein & Lunetta, 1982) and can be seen as such a subject-specific operation (Bader & Schmidkunz, 2002). Results of research on learning from experiments in school are controversial (Hofstein & Mamlok-Naaman, 2007). Some studies criticize laboratory work to be unproductive; others report the possibility of meaningful learning in experimental situations. Most of these studies are conducted under experimental conditions to evaluate only one criterion or some few isolated criteria which enhance students' performance in experimental phases. However, there is a lack of research studies in regular chemistry instruction to identify experimental-specific quality criteria.

RESEARCH QUESTIONS

Based on the theoretical background the aim of the project is to translate the results of the research on general instructional quality to specific characteristics in chemistry education (in particular to the experimental phases) to identify experimental-specific characteristics of quality that enhance the learning process. This is achieved by observational research (video-analysis) based on a category system.

The following research questions are due to the objectives:

- Which general characteristics of instructional quality can be transferred to experimental phases in chemistry education?
- Which requirement of intervention can be derived from observed chemistry lessons?
- Which effect does the intervention have on the achievement, interest and motivation of the students?

METHODS

Procedure

The study consists of two parts. In the first part, regular chemistry lessons have been observed to test first ideas about experimental-specific quality criteria. These ideas were used to develop a video coding system and to plan an intervention study aiming at optimizing the run of the presented lessons. In the second part (intervention study), the teachers were trained by video feedback on the first lesson and asked to teach the same content again in another class, but to optimize the lesson according to the quality criteria. To describe experimental phases in chemistry education, 18 regular lessons with experimental phases have been videotaped in the first part in 2008/2009 (10^{th} grade; mid-school; topic *alcohols*). The teachers (N = 15) were instructed to demonstrate a typical chemistry lesson under the condition that at least one experiment should be conducted. These video-data were analyzed based on a category system. These 15 classes (18 lessons) were the first control-group. One year later (school year 2009/2010), 10 of the 15 teachers were consulted for an intervention in which the characteristics of quality in experimentation phases were given. In addition, data from another direct control group (parallel classes without intervention), were collected previous to the intervention group to make sure that there were no additional influencing factors apart from the planned intervention (e.g. new school books, new facilities etc.).

Instruments

This category system (fig. 3), consisting of a low-inferential and a high-inferential component, has been conducted and evaluated before. It is developed chemistry-specific based on general quality criteria, the systemic model of quality in education and results of research studies on experimentation. The objectivity and reliability was proved by the inter-rater reliability (K: .55-1.0; ICC_{unjust} = 0.82 ($F_{1,220}$ = 23,72; p < .001). The validity was proved by the comparison of extreme groups (high points vs. low points in terms of quality). It could be shown that the group with the high score has a significant higher learning achievement than the group with the low score. So the conditions for an objective, reliable and valid category system are fulfilled.

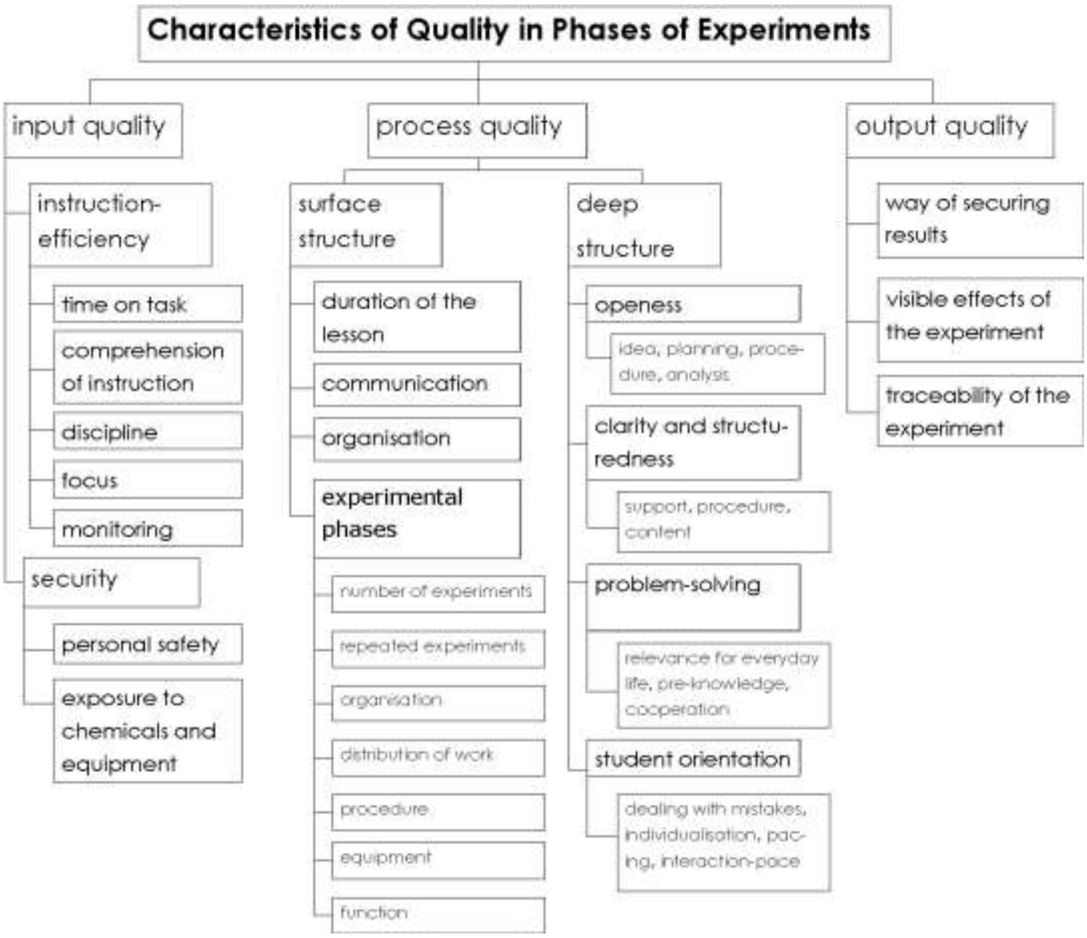

Figure 3: Category system

To be able to explain chemistry instruction and not only to describe it, video-analysis should be completed by using further criteria like interest, motivation, intelligence or capacity (Seidel et al., 2006). To consider this, students' characteristics (learning achievement, motivation, interest) have been acquired in a pre-post test design. Additionally, the cognitive abilities (Heller & Perleth, 2000) and the knowledge of scientific procedures (Klos et al., 2008) have been collected, so the test data could be analyzed more precisely. The second study (intervention study) was conducted one year later (2009/2010). The same teachers as in the first study participated in the intervention study and the same test instruments were used. In the intervention study, the experimental phases were enriched with the possible quality criteria from the first study using a short teacher training. The students of the first study formed the control-group and the students of the second study the intervention group.

RESULTS

From the first data collection, among others, the following criteria with a positive influence on the learning outcome were derived: *amount of students' talk, students' explanations, hypothesis testing, instructional efficiency, problem-solving, traceability of the experiment.*

Using the video training, the teachers were instructed to improve these criteria in their lessons. The results of the second video analysis (intervention study) show that the training was successful. The descriptive comparison of the intervention-group and the control-group (video-analysis) illustrates the increase of quality criteria in the intervention-group. Among others, significant higher values concerning these quality criteria could be shown for the categories *statements of students, hypothesis testing, instructional efficiency, problem-solving* and *traceability of the experiment*. Furthermore, it could be shown that the intervention-group has a higher learning achievement than the control group (t (420) = 3.181; p = .002, d = .31). This result proves the assumption that the selected criteria are useful to improve the quality of chemistry lessons and students' learning. A difference between these groups concerning the motivation and interest of the students could not be found (p > .05) in general, while the situational interest of the intervention-group was significantly higher than the situational interest of the control-group (t (275) = 4.196; p < .001; d = .54). A mediation-analysis was conducted to prove the situational interest as a mediator for the learning achievement. The result of the mediation-analysis showed a partial mediation.

CONCLUSIONS AND IMPLICATIONS

General quality criteria of instruction could be transferred to experimental phases in chemistry education (first study). An improvement of the experimental phases - based on the quality criteria – is attended by an increase in learning achievement and situational interest (second study/intervention). An increase in motivation and general interest could not be shown. One explanation is that motivation and interest are strong constructs (Krapp, 1999) and not to be changed in one lesson. Maybe a longer period of intervention might have an influence on motivation and interest of the students.

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Learning Physics in Daily Life Contexts: A Concept for Effective Learning and Teaching

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Abstract: Our study evaluated a context-based unit on carbon dioxide gas sensors. The major goal was to develop a context-based approach. That sought to help students create new knowledge about the key concepts of the operating mode of carbon dioxide gas sensors and transfer their knowledge between different contexts. To this, three issues of learning physics of sensor technology were specially considered.

First, the sensor was used within a context which is expected to be meaningful and relevant to the students. Such the context of poor indoor air quality in classrooms was selected. It should provide an answer to the students' questions: "How does a carbon dioxide gas sensor work?" and "Why should I learn this subject?".

Second, the use of different forms of representation such as texts and pictures should help students to construct an individual multiple mental representation of the content.

Third, workbook-exercises presented in different forms of representations should help learners to apply their knowledge and to get a deeper understanding of the key concepts of the subject matter.

The influence of contexts and exercises on knowledge acquisition and knowledge transfer to new situations was tested by using a pre-, post-, and follow-up design. Data from 170 participants were collected and analyzed by using a MANOVA. The results of the overall MANOVA showed a significant effect of the representation format of exercises on the acquisition of knowledge. Students who did exercises that were presented by a picture-based format performed better on knowledge tests than those who did the same exercises presented by a text-based or mixed format. For the acquisition of declarative knowledge the context was not the crucial factor. However, students who learned within the context 'indoor air quality' performed better on transfer tasks than those who learned without anchoring learning and knowledge to such a context.

Keywords: context-based, sensor technology, exercises, forms of representation

INTRODUCTION

In 1929 the inert knowledge problem was described and coined by A.N. Whitehead (Whitehead, 1929). He used the term 'inert knowledge' when describing the failure of knowledge to transfer to new situations. According to this, inert knowledge is knowledge that can be recalled when people are specifically prompted to remember it. But it cannot be used to solve problems in new situations. There is a gap between the recall of knowledge and the use of knowledge. It is quite possible to acquire knowledge but to be unable to use it. Well, it is a long time ago since Whitehead said this. But today the problem is the same. In 2005 Mandl & Kopp noted that, "Little has changed since A.N. Whitehead wrote this over 75 years ago" (Mandl & Kopp, 2005, p. 15). Six years later Gilbert et al. (2011) discussed five major problems in science and mathematics education. They argued, among other things, that "Students often cannot transfer knowledge to situations other than the one in which it was learned" (Gilbert et al., 2011, p. 817).

The ‘inert knowledge problem’ was analysed by Renkl et al. (1996). They described possible reasons for the acquisition of inert knowledge. Three categories of explanations including some deficits that are expected to influence the acquisition of inert knowledge were discussed by Renkl et al. (1996):

- The first one comprises explanations with respect to deficits in the structure of knowledge. De Jong et al. (1996) distinguish four types of knowledge: situational knowledge, conceptual knowledge, procedural knowledge, and strategic knowledge. The term ‘deficits in the structure of knowledge’ means that the relevant knowledge is not available. Some possible reasons could be that students learned isolated facts, concepts or algorithms. It is also often explained by insufficient conceptual knowledge. In this case, the quality of the conceptual knowledge is inadequate. For example, students can give definitions, and principles about the solution of a problem, but they are not able to give a step by step guide for solving this problem.
- The second point is about the situated nature of all learning. That is to say, knowledge and mental representations are dependent on context. Knowledge is linked to the context in which learning takes place.
- The third point is about the access of knowledge. In this case, the relevant knowledge is available. But it can‘t be used, because of lacking control over their own meta-cognitive processes. For example, students must be motivated to use their skills, their learning strategies and their knowledge. Therefore they must become interested. The relevant skills are not applied or not available.

In summary without additional arrangements students do not have the ability to apply what they have been learned in a new context and the transfer fails.

In the 90s the CTGV (1997) provided examples of learning environments that focused on the idea of overcoming inert knowledge. They used the concept of anchored instruction and designed, among other things, the Jasper series. They assumed that the use of mathematics in authentic contexts supports the students’ reasoning, problem solving, and communication skills (CTGV, 1997). The effectiveness of anchored instruction was evaluated by various researchers. Research on Jasper series suggested that students who receive Jasper problems perform better in problem solving, show less anxiety toward mathematics, are more likely to see mathematics as relevant to everyday life, more likely to see it as useful, and more likely to appreciate complex problems than do students who receive traditional one-step word problems. They also showed that transfer does occur to analogous problems in different contexts (CTGV, 2000). The Jasper series were modified and follow-on projects were developed in the last years. Results of research on these projects (e.g. “Scientist in Action”, “SMART“ …) are presented and discussed by CTGV (1997, 2000). In Germany the group around Kuhn (2010) modified the concept of anchored instruction, too. The essence of their approach is to “anchor” instruction in the context of real newspaper articles. They acknowledged the results of CTGV and evaluated large effect sizes. Kuhn (2010) showed that students who receive the modified anchored instruction concept perform much better on transfer tasks, physics achievement tests, and show higher motivation than do students who receive traditional textbook units.

RATIONAL

In conclusion, we know that there are three main reasons for the acquisition of inert knowledge and we also know that the concept of anchored instruction seems to be useful to overcome these causes. But, the research to date in the field of anchored instruction has tended to focus on one or two causes. It seems necessary that all three causes should be addressed by a general concept. The aims of our project were: ...

- first, to overcome the 'inert knowledge problem'. From this we developed a concept for physics courses that was thought as likely to consider the three causes for the acquisition of 'inert knowledge' and to make students' knowledge useful for other contexts by transfer. For that purposes the content and special workbook-exercises were presented in different forms of representations. Both were positioned within a realistic and authentic context.
- second, to make subject matter more relevant for students. To this, a context-based unit on non-dispersive infrared gas sensors was developed. The subject matter was positioned within an everyday life setting. The context was formed around the main application of these sensors.
- third, to undertake a comparative study to examine the effectiveness and practicality of our concept. Especially the influence of our concept on the acquisition of knowledge, transfer, students' motivation, learning strategies, and estimation of authenticity and relevance with regard to content.

RESEARCH QUESTIONS AND HYPOTHESES

The research questions driving this project were:

- How does the use of our special workbook-exercises (presented in different forms of representations) influence knowledge acquisition and learning activities?
- How does the use of authentic applications of sensors influence transfer of knowledge and motivation?

Corresponding to this, the following hypotheses were tested:

- Students who do exercises that are presented by a text- and picture-based format perform better on knowledge tests than do students who receive exercises that are presented by a picture-based or text-based format.
- Students who work with exercises that are presented by a text- and picture-based format carry out more cognitive activities than do students who receive exercises that are presented by a text-based or picture-based format.
- Learning within authentic applications of sensors leads to better performance on transfer tests than learning without linking knowledge to authentic applications of sensors.
- Learning within authentic applications of sensors leads to higher motivation than learning environments without authentic applications.

METHODS

Sample

170 students (88 females, 80 males; ninth-grade) from three secondary schools, ranging in age from 14 to 15 years, participated in this study. They all came from Baden-Württemberg (southwestern Germany). The students were randomly sampled to experimental and control conditions. Before implementation of a two-week context-based unit on non-dispersive infrared gas sensors the students were not taught the physics or the applications of the sensor. So they had no knowledge of this. The teachers who participated in this study were trained to use the sensor and in applying our concept.

Design

We used a pre-, post-, and follow-up design. We implemented a 3x2 factorial design with format of exercises and application as factors. The factor A "format of exercises" had three levels. The factor B "application" had two levels.

		A: format of representations of exercises		
		picture & text	picture	text
B: application of sensors	authentic	I (n=33)	II (n=29)	III (n=27)
	not authentic	IV (n=27)	V (n=27)	VI (n=27)

Table 1: Design

For example, the first group consisted of 33 students. They received a treatment with exercises that were presented by a picture- and text-based format. And the treatment they got was based on an authentic application of the sensor. All together, we evaluated six treatments, whereof three treatments are used as control groups.

Research Setting and Procedure

We developed a two-week unit on **n**on-**d**ispersive **i**nfra**r**ed gas sensors that contained both the operating mode of the sensor and their application in everyday life.

In its entirety, the two-week unit consisted of four learning steps across four hours. The students received a workbook for all learning steps describing the activities to be performed. The first of the four steps required students to identify the problem of poor indoor air quality. The second learning step highlighted the operating mode of the sensor. Using a workbook, students were introduced to the key components and the functionality of **n**on-**d**ispersive **i**nfra**r**ed gas sensors. In the third step, students worked in groups and collected data to explore the increase of carbon dioxide in classrooms during a lesson. The fourth learning step required students to develop their own personal plan to regulate and control the air conditioning. The experimental and the control treatments were instructed by their physics teacher or by the author for 90 minutes each week.

Data Sources

We used a pre-, post- and follow up – test design to explore students'

- content knowledge,
- transferable knowledge,
- current motivation towards physics,
- learning strategies,
- self-efficacy,
- estimation of authenticity, and
- estimation of relevance with regard to content.

For control we also assessed students' gender, age, and marks in mathematics, German language, and physics. The items of all questionnaires were multiple-choice questions (typically three distracters were offered) or rating scales ranging from 'strongly agree' to 'strongly disagree.

Pre-Test

Students' current motivation towards physics und learning strategies was assessed with a questionnaire contains four standardized tests.

- The *current motivation-scale* was derived from an instrument used and developed by Prenzel et al., (1996). This test instrument having 15 questions contains five subscales: (1) intrinsic motivation, (2) extrinsic motivation, (3) identified motivation, (4) unmotivated, and (5) introjected.

- The l*earning strategies-scale* was derived from an instrument used and developed by Seidel et al. (2005). This test instrument having nine questions contains three subscales: (1) rehearsal, (2) elaboration, and (3) organization.
- The *self-efficacy-scale* was derived from an instrument used and developed by Pekrun (2005). This test instrument having six questions.
- The *estimation-of-authenticity-scale* was derived from an instrument used and developed by Kuhn (2010).
- The *estimation-of-relevance-scale* was derived from an instrument used and developed by Seidel et al. (2005).
- Students' *content knowledg*e was assessed with a questionnaire contains 38 questions and five subscales: (1) voltage, (2) construction of the sensor, (3) operating mode of the sensor, (4) operating mode of thermocouple, and (5) infrared radiation. The test items were developed and tested by the author. An alpha reliability of .71 was found.

Between the two weeks:
After one week, students received a short questionnaire including the following instruments:
- current motivation scale,
- learning strategies scale,
- estimation of authenticity scale, and
- estimation of relevance with regard to content scale

Post- und follow-up-test
Students' transferable knowledge was assessed by a post- and follow-up-test. The questionnaire had 20 questions contains three subscales: (1) construction of a methane-sensor (2) operating mode of a methane – sensor, and (3) increase of carbon dioxide in classrooms and elevators.

Data Analysis
To determine, if there were any statistically differences between the groups on the dependent variables a MANOVA was used.

SELECTION OF SOME RESULTS AND DISCUSSION

Equivalence of pre-test scores
A 2x2x2 MANOVA on pre-test scores indicated no differences between the experimental and control groups (treatment by gender by class).

Results of the Overall MANOVA
The results of the overall MANOVA were statistically significant. Using the Pillai's trace, there was a significant main effect of „format of representation of exercises" and of „authentic applications" on the observed variables ($F_A(8,384)=10{,}741$; $p=.005$; $\eta^2=.074$; $F_B(4, 159)=16{,}949$; $p=.000$; $\eta^2=.101$; $F_{AxB}(8,384)=5{,}899$; $p=.018$; $\eta^2=.041$). The multivariate test 'Pillai's Trace' tests the null hypothesis of equality among the group means for the effect of the factors A and B on the weighted linear combination of the dependent variables. So it represents the proportion of variance in the weighted linear combination of the dependent variables. Thus the larger the value of Pillai's Trace, the greater the difference among the groups on weighted linear combination of the dependent variables.

In the following explanations we limit ourselves to the first research question and hypothesis.

How do the use of our special workbook-exercises (presented in different forms of representations) influence the acquisition of declarative knowledge?
It was hypothesized that participants who do exercises that are presented by a text- and picture-based format perform better on knowledge tests than do students who receive exercises that are presented by a picture-based or text-based format. However, the results of this study did not show that the students who worked with both types of exercises performed better on knowledge tests than the other students.

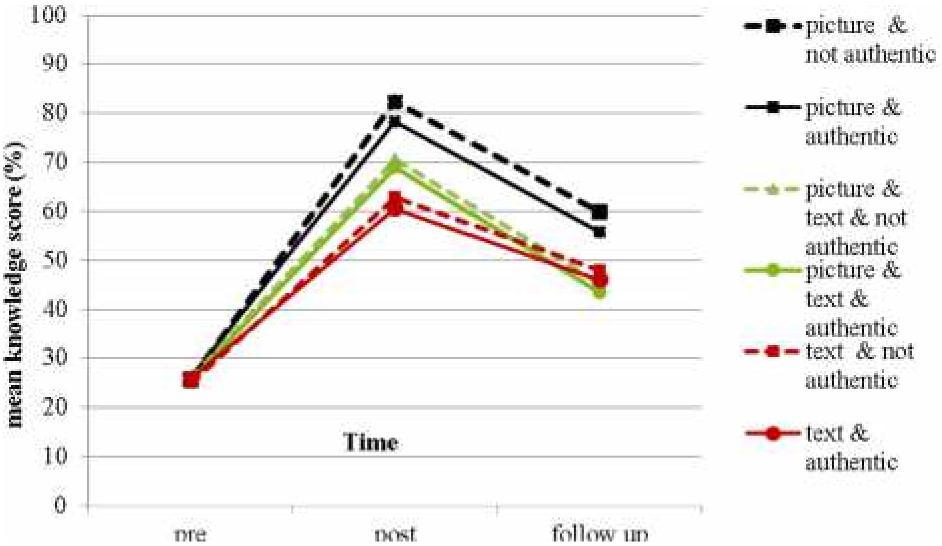

Figure 1: The multiple line chart presents the results of the content knowledge questionnaire among the three measures and the six groups.

The multiple line chart above (see figure 1) shows the mean knowledge score (declarative) of all six groups. All scores are presented in percentage quotation. If a student answers all questions correctly, he or she will get 100% of the points. The declarative knowledge was assessed in the pre- post- and follow-up-test. What we can see from this chart is that students who did exercises that were presented in a picture-based format performed better on knowledge tests than those who did exercises that were presented in the combined format and those who did exercises that were presented in a text-based format.

Discussion
There are several possible explanations for this result. One might be that exercises that are presented in a picture-based format are more attractive for students than exercises that are presented in a text-based format. Another possible explanation is that students who did the exercises that were presented in a picture-based format did their tasks in a short time. So in half an hour, they performed nearly twice the number of exercises than students who did the exercises that were presented in a text-based format. They took a longer time to do their tasks.

How does the use of our special workbook-exercises (presented in different forms of representations) influence learning activities?
It was hypothesized that students who work with exercises that are presented by a text- and picture-based format carry out more cognitive activities than do students who receive exercises that are presented by a text-based or picture-based format. The following multiple line chart (see figure 2) shows the mean learning activity score of the three groups. As you can see from this chart students who did exercises that were presented in a text- and picture based format estimated their cognitive activation as well as students who did the other exercises.

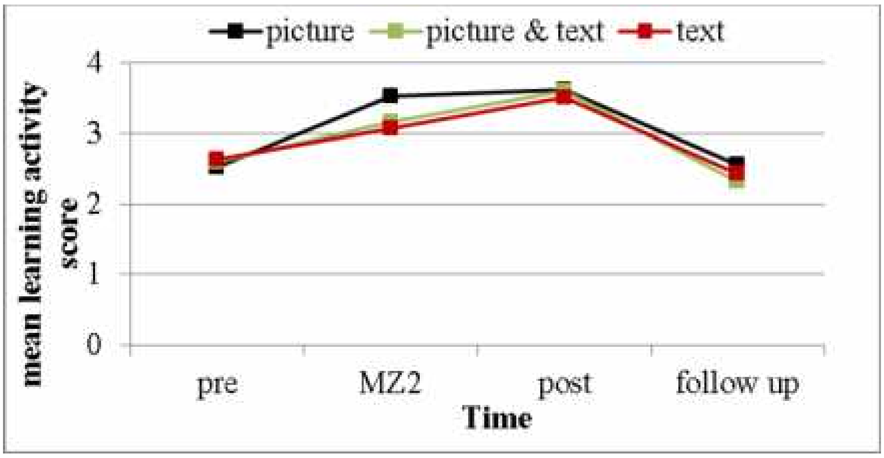

Figure 2: The multiple line chart presents the results of the learning activity questionnaire among the four measures and the three groups.

Discussion

This result may be explained by the fact that it's difficult for students to give a realistic self-evaluation of their cognitive activities and learning strategies. It seems that they tend to an overestimation of their own capabilities. So the data must be interpreted with caution.

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PART 4: ICT AND OTHER RESOURCES FOR TEACHING/LEARNING SCIENCE

<u>*Co-editors:*</u> *Patricia Marzin and Jari Lavonen*

Design and use of resources and environments for teaching/learning science: ICT and TEL in science education, other resources (science textbooks, teaching sequences, etc.).

This part corresponds to strand 4. It contains 18 papers.

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ICT AND OTHER RESOURCES FOR TEACHING/LEARNING SCIENCE

THE CONSTRUCTION OF MEANING IN SCIENCE CLASS WITH USING A DIGITAL LEARNING OBJECT.

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Abstract: In this article, the purpose will be argue and discuss dialogics interactions that happen in a science class of basic teaching, and if they had produce means with the prop of a Information Technology and (IT). These interactions will be analyzed under the point of view of an analytic tool (MORTIMER and SCOTT, 2002) with the Bakhtin dialogics forecasting.

Keywords: science class, semiotic mediation, speech genres.

INTRODUCTION

In the lastest years, the Science Teaching has enfatized the Human being as active participant in the context in that lives. The influence is the both directions. Looking at this situation, the focus is on the language. According to Vygotsky (2000) the language is an instrumental activity. So, researches in Sciences Educating with its center in the nature of interactions between teachers and students to build scientific knowledge has grown since the late decade (MACHADO, 1999; MORTIMER, 2000; SUTTON 1997; MARTINS et al, 1999). In this article, the purpose will be argue and discuss dialogics interactions that happen in an science class of basic teaching, and if they had produce means with the prop of a Information Technology(IT). These interactions will be analyzed under the point of view of an analytic tool (MORTIMER, 2002) with the Bakhtin dialogics forecasting.

LEARNING OBJECT AS A METACOGNITIVITY TOOL

This work has an objective to argue and discuss briefly that through interactions between teacher and student. It was possible to aid in the building of meanings about the digestive system in a classroom with the use of an object to approach built with the focus to teaching for improve metacognitive~~-~~tools of students, taking like reference Bakhtin theories. ITs are instruments created by men to act on the nature or the material reality (VYGOTSKY, 1991). Since the last decade studies come indicating that the use of a learning object (LO) can to present~~ate~~ a sociodiscursive built, when this presents a dialogic relations between student and teacher (KOZULIN, 2003; AFFONSO, 2008). In this work interest us is how the Theory of L.S Vygotsky realize this language.

Semiotic Mediation in Vygotsky and the sign for Bakhtin.

To Vygotsky, the language is an instrumental activity and means fundamentally two things:

1 - That it is ever mediated by instruments,

2 - and these instruments are created by men in function of the nature of actions planned by him.

In this way, to Bakhtin, these instruments are signs and then, ideology's products. And, as the ideology has a meaning and it is a part of a reality (natural or social reality) as all physic body. The sign is an instrument of production or a consumption product. But otherwise of them it also reflects and refracts another reality that it is exterior. The existence of sing is nothing more than the materialization of this communication. In this fact is that consist all of nature of ideological sings. But this semiotic area and this continuous paper of social communication as a conditioning factor didn't appears in anyone place more clear and complete than in the language. The word is an ideological phenomenon in excellence (WERTSCH, 1991). It meeting point between Vygotsky and Bakhtin theories is the semiotical mediation. To Vygotsky it's grounded beyond the language, it is in interactivies' situations. These situations become viable the mechanism of internalization, that means, the inner reconstruction of an external operation (VYGOTSKY, 2000).

In this article, the purpose will be argue and discuss dialogic interactions that happen in a science class of basic teaching, and if they had produce means with the prop of an IT. The IT used in this work was the LO, Route food (Figure 1). These interactions will be analyzed under the point of view of an analytic tool (MORTIMER and SCOTT, 2002) with the Bakhtin dialogic forecasting.

Figure 1 – LO's Route food screen

METHODOLGY AND RESULTS' DISCUSS

The presenté analysis in this article it's grounded in the analytical tool of Mortimer and Scott (2002). This tool shows how the kinds of communicative approaching are produced through teachers interventions. Analyzing the actuation form as the teacher done to guide the interactions that aid in the building of meanings in science classroom. The tool is the product of a tentative to develop a writing language do describe the genre of discuss (BAKHTIN, 1986) in the science classrooms. The survey was conducted in a State school with elementary school students from 13 to 14 years. The methodology used in this research was qualitative type, which contain detail data and they are related to people, places and talk, and it demand complex statistic treatment (BOGDAN & BIKLEN, 1994).

Table 1 – Analytical Tool to analyze the interactions and the production of meanings in science class (MORTIMER and SCOTT, 2002).

Analysis aspects	Teachin' phocus	Approaching	Acts
	Teacher' s intents	communicativity approaching	Interation Patterns
	Contents		Searcher's interventions

In this article the emphasis was given in the teacher's intents and in the teacher's interventions. In these aspects were really happen these dialogical interactions between teacher and student. Nevertheless, the contents of LO was teaching focus being elaborated in the wholeness of process of human digest. The communicative approaching occurred through the use of this IT. The approaching having like mainly: the dialogical and the authority- (WERTSCH, 1991).

In these aspects were really happen these dialogical interactions between teacher and student. Nevertheless, the contents of LO was teaching focus being elaborated in the wholeness of process of human digest. The communicative approaching occurred through the use of this IT. The approaching having like mainly: the dialogical and the authority (WERTSCH, 1991).The dialogical approaching happened when students told the trajectory of the feeding contents through the gastric-intestinal handle (Figure 2).

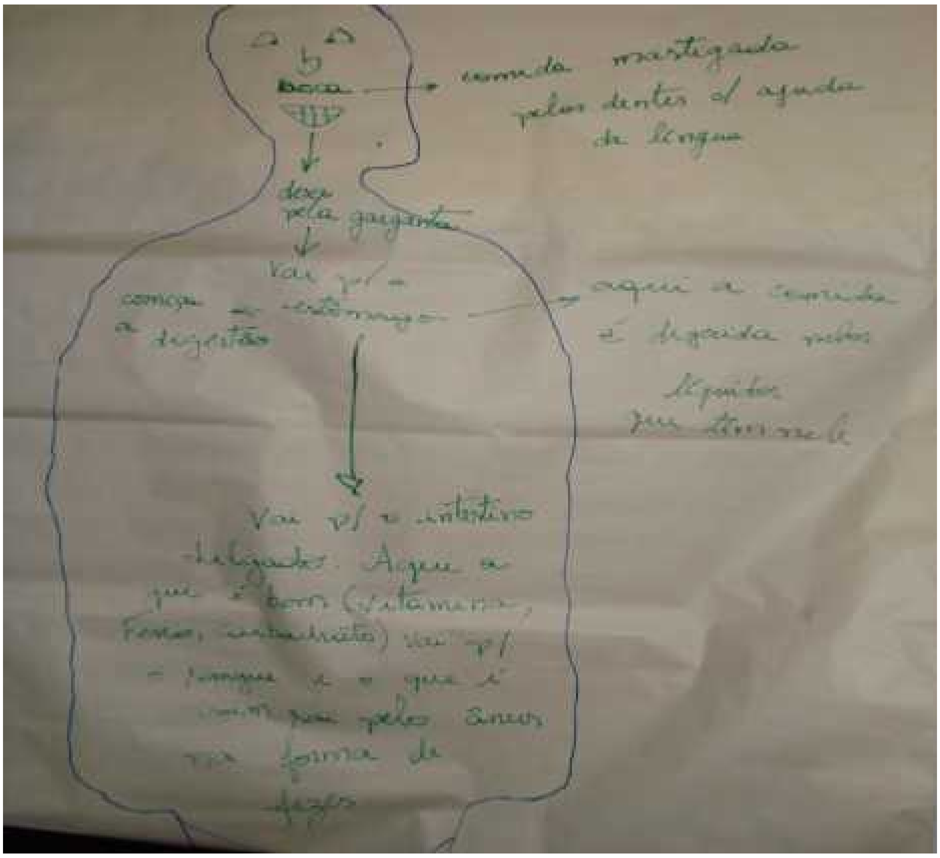

Fig. 2 – Students'_drawing about told the trajectory of the feeding.

But traces of authority approaches have been saw when the searcher putted only her point of view and only her voice was heard. In this episode a bigger interaction between searcher and students were done, with bigger relevancy to the student's initiative. However, the mainly objective of this study was the teacher's intentions. The problem was to engage students in the way intellectual and emotional to build meaning through the LO using.

However, the mainly objective of this study was the teacher's intentions. The problem was to engage students in the way intellectual and emotional to build meaning through the LO using. The students' visions about the digestive system of human being were explored by the oral and writing language, this last in the way of drawings. The LO introduced the scientific concepts. In this way, the technology was incorporated to the social plan of classroom. The simulations and interactive images from LO given support to the concepts' internalization and the building of students own meanings about the topics that were studied.

Beyond the dialogic/authority approaching, the simulations and interactive images' LO furnished metacognitive tools to aid in the building of meanings started the concepts exteriorization, as enunciated, and his posterior internalization. The internalized concepts could be watched when students named the organs of the digestive system in the final activity of the class.

During the searcher's intervention analyzed that to explore ideas about students' digestion watched that the signs that was presented by the students was only a reflex of theirs reality (BAKHTIN, 1986). In the intervention were explored students' ideas about theirs nourishment habits and about the act of to choke - a concept raised by the students. Starting this, the question selected about to choking trade the main expressed: the physician process of the closing of the glottis (Figure 3).

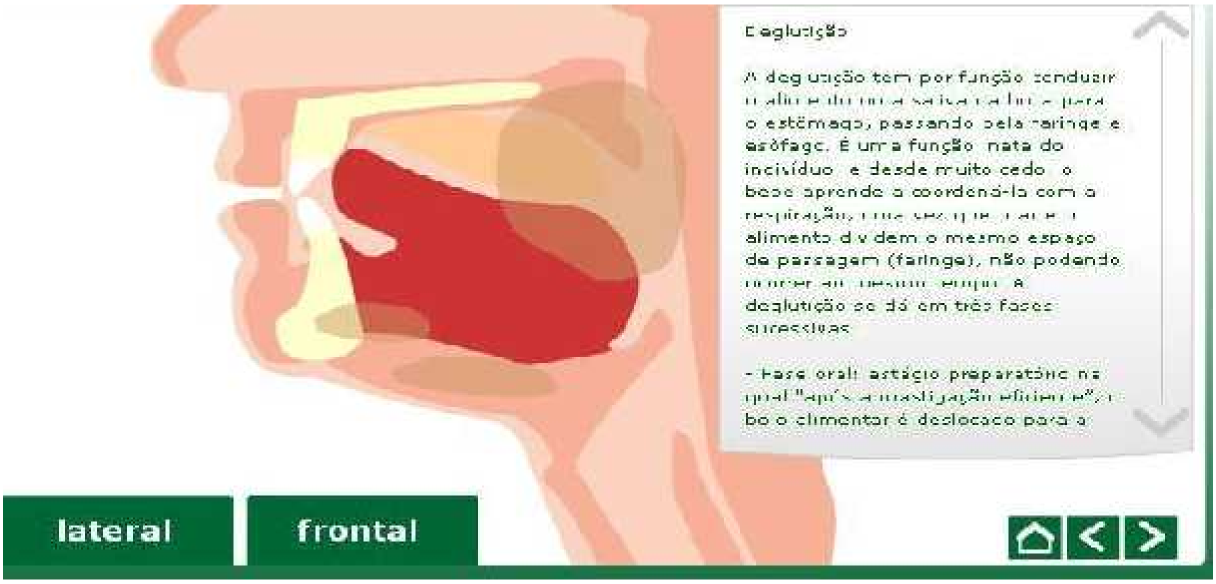

Fig. 3 – Physician process of the closing of the glottis screen visualization.

In this point was requested to the students that repeat the scientific concept. In this way, the internalizations' steps described by Vygotsky (2000) could be watched. To the repeating this concept the students start to re-organized the ideas of them. To Vygotsky (2000) an external activity is rebuilt and begins to happen internally. By the way students attributed the fact of feeling suffocated to the coming of nourishments through trachea with the sentence:

Student: *the nourishment comes through the wrong hole!*

Being follow by the exclamation:

Student: *Blame this we choke!* That means to them don't close the glottis.

CONCLUSIONS AND IMPLICATIONS

Ending, signs can be realized as internalizated since that all the sign is part of the reality that enunciated it, to Bakhtin (1986). This work was influenced by researchers that have studied the interactions in the sciences class and in the way as new meanings are developed through of ways of verbal and no-verbal expressions. Patterns of discuss that take advantage of others in the sciences classrooms are so several and likewise they consist in a genre of steady discuss that will be the focus of analyses of ours (MORTIMER and SCOTT, 2002). To sum up the results through done activities was possible to watch Bakhtin premise (1981) where the *sign opposite itself to another sign the conscience herself only can rise and assure itself like reality through material incarnation of signs*, however, students took conscience about concepts over bodies organs of digestive system when they named them in a draw in this way. students. Ending, it understood that the interactions that happen were so primary genre (students' speeches, prejudicing about scientifics concepts) and secondary genre. The discursive genre was presented in the whole LO was the secondary (ideological) genre. And so, the teacher intent to teach the content was concluded and a scientific discuss was done.

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TWO GRAPHS DON'T MAKE A WHOLE: THE SYNTHESIS OF DISPARATE GRAPHS IN INQUIRY-BASED SCIENCE LEARNING

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Abstract: A comparative synthesis of multiple graphs is a common practice in scientists' work as well as in everyday contexts. This process involves elements of a meta-analytic approach, such as computation of effect size measures. We present findings from classroom enactments in Israeli and Cypriot high schools, in which cultivating students' graph meta-analysis skills was one aspect of fostering scientific literacy through an inquiry-based learning environment on socio-scientific dilemmas. The topic of the environment was "How can we choose the best smoking cessation aid?" and it required students to compare four smoking cessation treatments using graphs modified from recently published scientific articles. The specific task which is the focus of this paper required students to merge data from two line graphs, in order to rank the treatments by their efficiency, defined as abstinence from smoking. In contrast with a previous pilot study, most of the students ranked the treatments correctly, and an examination of students' justification for their rankings indicated a significant improvement in the quality of arguments. A comparison of pre- and post-enactment responses to graph synthesis tasks showed a significant improvement but on the other hand indicated that graph synthesis is a demanding task for most of the students, even following a focused intervention. Our findings highlight the challenges that learners and teachers encountered and their implications for future instruction and design.

Keywords: inquiry-based learning, socio-scientific issues, graph-reading skills, graph synthesis, adapted primary literature

INTRODUCTION

Scientists conducting a literature review or lay-people searching the web often encounter the same conundrum: making sense of an abundance of data sources that provide partial answers to their question. This creates a need to compare and synthesize the different pieces of information into a coherent whole. For example, different scientific articles that deal with similar research questions may test different variables, or operationalize the same variables in different ways. In such cases, a simple aggregation of the information can yield erroneous conclusions. Instead, meta-analytic steps, such as using effect size to normalize findings to a common scale, need to be taken to juxtapose and synthesize the information.

Synthetic skills may be considered a subset of procedural scientific literacy skills (Bybee, 1997), because they involve credibility judgments and allocation of different weights to multiple data pieces. Despite the fact that the use of meta-analytic methods and effect size measures has become quite common in current scientific work, these issues are not typically addressed by high school curricula. In line with current definitions of scientific literacy (e.g., OECD/PISA, 2003) we believe that it is important to expose students to synthetic aspects of the scientific process, in addition to the more prevalent analytical aspects. However, by this we do not mean that students should be taught explicitly how to conduct a meta-analysis or how to compute effect sizes (i.e., how to "do science", Millar & Osborne; 1998), since this procedural knowledge is only relevant for a small minority of the students who will become scientists in the future. Instead, our objective was to confront students with situations which require data synthesis, and lead them to articulate a solution, using an inquiry-based approach. Specifically, we chose to focus on synthesis in the context of graph comprehension (Bertin, 1983) in a process we refer to as *graph meta-analysis*.

Graphs are central communication devices in most empirical reports, especially in science but in other contexts as well. Non-scientists encounter graphs on a daily basis at work, in the popular media and the internet, even in advertisements. We use the data represented by these graphs in order to draw conclusions and make decisions. We may use a graph to choose which cereal brand to buy, and we may use another graph to decide whether or not to spill sewage into the river. Not surprisingly, graph interpretation and production skills are emphasized in national science standards (NRC, 1996). However, several studies have shown, several studies have shown that full competence in reading and producing graphs is not achieved even by college and university graduates (Bowen, Roth, & McGinn, 1999; Leinhardt, Zaslavsky, & Stein, 1990). Bowen and Roth (2005) found that pre-service teachers, most of whom had a BSc degree, lacked basic skills in graph interpretation, and reached the sad conclusion that "preservice teachers do not seem to be ready to teach data collection and analysis in the way suggested by reform documents." These findings highlighted the need for concerted instructional attention on graphic literacy skills (di Sessa et al., 1991; Shah & Hoeffner, 2002). If making sense of a single graph is a difficult task, then having to glean information from a comparative synthesis of multiple graphs is even more challenging. This activity, which we refer to as *graph meta-analysis*, is a common feature in the work of scientists (and other professionals) when they analyze their own data or when they review data presented by others. A similar challenge is faced by citizens who encounter graphs when they make decisions about science-related issues based on information that they garner from news reports, web searches or other similar sources.

In order to present several graph comprehension tasks within a realistic scenario, we designed a web-based learning environment (LE) using the STOCHASMOS (Kyza & Constantinou, 2007) platform. The topic of the environment was "*How can we choose the best smoking cessation aid?*" This environment required students to compare four pharmacological smoking cessation treatments using data (graphs) modified from recently published scientific journal articles. This report focuses on a specific task that required students to synthesize data from two line graphs, in order to rank the treatments by their efficiency, measured as abstinence from smoking. Each graph contained data from a different clinical study, in which *only 2 or 3* treatments were compared, in addition to a placebo control group. Thus, the overall ranking of *four* available treatments required a process of meta-analysis, involving measures of effect size.

Our research questions were: (1) Will high-school students be able to solve graph synthesis tasks correctly, and if not, what will be their difficulties? (2) Can an inquiry activity serve as an effective tool for teaching students to handle such tasks? (3) Can elements in the design of the inquiry environment effectively fill in the role of the teacher and serve as learning scaffolds? (4) Is there a critical role for the teacher in such learning activities?

METHODS

A first version of the Nicotine Addiction LE was tested in a pilot study in one 10th grade class from a private school in a lower-middle SES Arab town (N=35). The revised version was tested the in two Israeli 10th grade classes and one Cypriot 11th grade class. One Israeli class was from the same Arabic-speaking school (class Q, N=22) and the other from a public school in a high SES Jewish suburb in central Israel (class R, N=16). The Cypriot class was from a high SES Greek-speaking school (class C, N=19). Students worked individually (class Q) or in groups of 2-3 students each. Only 49 students completed pre- and post-enactment individual assessment questionnaires. Two out of the three teacher participants (teachers of classes Q & C) were members of the Israeli and Cypriot development teams. We collected a variety of both process and pre/post data. Pertinent to the present report were the written responses to the "templates" (worksheets) in the computerized workspace, and responses on pre/postests. The pre/post-tests (two counterbalanced versions) included items on graph reading skills (some from PISA), items on conceptual knowledge about nicotine addiction and the use of control groups in clinical experiments, as well as items focusing specifically on graph synthesis.

RESULTS

We initially addressed these questions through a pilot study that presented students with the synthesis task, but with minimal scaffolding. Not surprisingly, the participants of the pilot study found the overall investigation very challenging and frustrating. Out of the whole class, only 11 pairs completed the synthesis task. None of the pairs ranked the medications correctly.Some of the specific challenges faced by students included: (a) Focusing on specific features of data in the line graph, e.g., differences between short-range and long-range effects of each treatment (8 out of 11 pairs); (b) Understanding the implication of different operationalizations for the same variable (all 11 pairs); and (c) Understanding the need to consider effect size (all 11 pairs). The teacher tried to provide scaffolding (Tabak, 2004) that was not provided by the computerized environment, through discussions with individual groups while they were working on their investigation, and through the asynchronous feedback notes that attach to the students' workspace. These mediations were not enough, so the teacher also held an impromptu whole class discussion that delved deeper into these issues. Obviously, the challenge for students became a challenge for the teacher. This challenge is amplified in settings where students work in small groups, each of which faces different obstacles in different time points, a situation that required the teacher to jump from one group to the other while other groups waited for their turn and sometimes lost their focus on the task and used the access to the internet for off-task activity. It is not surprising therefore that the teacher of the pilot class was exhausted at the end of each class, and this also affected her motivation to provide asynchronous feedback.

Following the results of the pilot study, we modified the contents of the LE. We added an introductory unit on placebo effects and control groups in clinical trials using a whole class discussion of case examples, and added prompting questions and hints in the text that accompanies the graphs in the LE. We made the graph representations easier to compare. Finally, we added special “synthesis templates” in the students’ computerized workspace that included questions designed to scaffold the analysis and synthesis of these graphs.

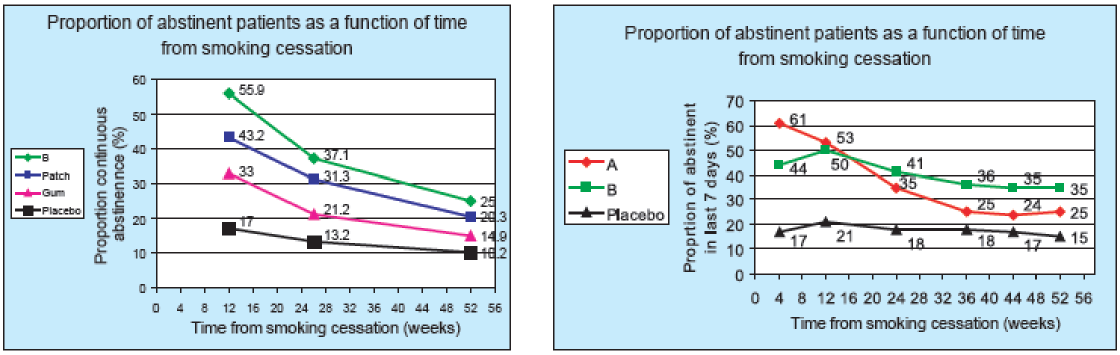

Figure 1: Graph synthesis task stimuli, following redesign

In contrast with the pilot study, most of the students ranked the medications correctly (58.3% compared to 0%). This difference was statistically significant (χ^2=10.69; p=0.001, Fisher's exact test). In class C, most of the teams did not complete the analysis of the smoking abstinence graphs due to time constraints, with the exception of two teams who proceeded ahead of their class but did not use the special the synthesis templates and, as expected, did not rank the treatments correctly. The highest frequency of correct ranking (85.7%) was observed in class Q, which was taught by the same teacher who taught the class of the pilot study. This teacher reported during the intervention that class Q was weaker than the pilot class, and its average grades in biology were significantly lower. Therefore it seems that differences in students' aptitude could not explain the differences between the pilot's results and those of the revised environment.

We also examined the arguments given by students to support their ranking. Even following the redesign of the environment, some students relied on the raw abstinence rates, and were unaware of the need to compute effect sizes, as can be seen in the following justification:

> "As we can see in the two graphs, the most efficient medication is B, because its results are the best, and the placebos in both graphs have the lowest results. We could compare them and therefore we merged the results. Medication A is ranked 2nd because in the other graph it is better".

Other students correctly justified their ranking by explaining how they computed the effect size:

> "I computed for each medication separately, according to the ratio between it and the placebo. I combined the results of the 1st and 2nd graphs, and the [medication] which got the highest ratio got the highest rank".

This justification was sometimes phrased with elaborate reference to the computation of ratios:

> "The computation principle: for every medication in the first part [=graph],divide the result at the end [=52 weeks] and divide it by the placebo. For example, medication B: 25/10=2.5. In the second part, divide by 15 instead of 10".

Some students understood that they had to compute a treatment to placebo ratio but apparently did not fully understand the meaning and utility of the result. For example, 4 students out of 14 from class Q computed the risk ratios of treatment B for the two studies, and then summed the result:

> "[For medication B] in the 1st table the ratio is 2.5 and in the 2nd table the ratio is 2.3, so the result is 4.8. The other ratios are computed as done for

> treatment B. At the end it is clear that treatment B is the best, with a ratio of 4.8 and the gum is the worst ratio – 1.5".

In order to quantify the quality of the justifications and compare between students' responses for the pilot stimuli and revised stimuli, we defined a scoring scheme and used it to score the justifications on a scale ranging from 0 to 10 (inter-rater reliability: 0.86 for pilot data, >0.9 for data following redesign). These scores indicated an improvement in the quality of arguments from an average of 1.45 (SD=0.80) to 3.79 (2.39). This difference was statistically significant (t-test, t=4.287, p<0.001).

There was more than a two-fold post- to pre-test increase in students' response to the graph synthesis question. But, these results still indicate that graph synthesis is a very challenging task, because even after the addition of specific instructional scaffolds only 36.7% of the students answered the posttest graph synthesis question correctly (compared to 16.3%). Similarly, we see advances, but not broad changes, in students' understanding of the synthesis process through their free-form responses explaining their solutions. We quantified the quality of students' justifications, and used a mixed design repeated measures ANOVA to test changes in justification quality. The main effect of time (pre/post intervention) was statistically significant ($F_{(1)}$=27.2, p<0.001). However, there was also a significant main effect of version order ($F_{(1)}$=8.29 , p<0.01) and a significant interaction between time and version order ($F_{(1)}$=15.02 , p<0.01). These effects are related to the fact that one version of the synthesis questions included an additional challenge for students, since it referred to an adverse (negative) effect of two medical treatments compared to placebo control. In such cases, the treatment with the larger effect size (i.e., treatment effect divided by control effect) should be considered worse than the treatment with the smaller effect size.

In order to assess whether the intervention improved students' conceptual knowledge about control groups in medical research, we used three multiple choice items in each version of the pre/post assessment battery, for two of which students were also required to justify their choice. Students showed an improvement from pre-intervention to post-intervention, from 37.4 (SD=20.3) to 48.2 (28.1) on a scale from 0 to 100 (t=2.51, 48 dof, p<0.05), but still did not internalize some of the central messages of the unit on control groups and placebo effects. For example, when asked about a case in which a treatment group was tested against a no-treatment control group, none of the students claimed that the observed effect may be solely due to a placebo effect. A repeated-measures ANOVA did not reveal any significant main effects of class and version order, or any significant interactions.

In order to assess whether the LE improves graph reading skills, we used two PISA tasks that involved graph reading but were not related in content to our LE (Greenhouse effect, task S114 and stickleback behavior, task S433). These tasks were included in the pre/post assessments of classes Q & R. Half of the students received the Greenhouse task prior to the enactment and the stickleback behavior task following the enactment, and the other half received the stimuli in reversed order. The answers were scored according to "Take the Test: Sample questions from OECD's PISA assessments" (OECD, 2009). Out of a possible score of 100 points, students improved from 41.96 (SD=30.47) to 58.93 (24.73). A paired t-test showed a significant difference between pre- and post-test (t=2.37, p<0.05). A repeated measures analysis also revealed a significant interaction with version order, indicating that the Stickleback assignment was more challenging than the Greenhouse.

CONCLUSIONS AND IMPLICATIONS

In conclusion, we are encouraged by our initial results that show that we have problematized the issue of graph synthesis for students. They recognize that one cannot simply aggregate disparate graphs without some form of adjustment. However, there is still much room for increasing students' understanding of the problems associated with simple aggregation, and with the specific procedures required for synthesizing graphs. The curricular and computer-based scaffolds we provided improved student learning, but these do not seem to be sufficient for broader and deeper learning gains. We hope that as a first step, our work will serve to include graph synthesis as an important part of the agenda for cultivating scientific literacy. In addition, we continue to explore how to scaffold and foster these skills, and how to integrate computer-based and teacher-provided scaffolds (Tabak, 2004).

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ANALYSIS OF ELECTROCHEMICAL CELLS PROCESSES SIMULATIONS. STUDENTS' POINTS OF VIEW.

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Abstract: We present a didactic and epistemological survey on the role and the relevance of the simulation in the understanding-modeling by the students of the working of the electro-chemical cells in closed circuit. Our step associates two approaches:

- on the one hand, an analysis of didactic and epistemological point of view of two applets of simulation of the electric conduction in an electro-chemical cell in closed circuit. One applet is conceived for teaching in Secondary school, the other for the university one.
- on the other hand, a semi-directive interview with students in the Upper Grade of Scientific Secondary School (France, 17-18 years old) explores both the observation of these applets, and the circulation of the carriers of loads and the selective drivers during the functioning of the cell.

We will debate about the didactic and epistemological relevance of the analyzed simulations that somehow seem to exceed the concrete experience, and to make the mechanisms of electro-chemical conductions "visible"/obvious to students.

Keywords: Electrochemical cell, electrical conduction, modeling, simulation.

BACKGROUND, FRAMEWORK, AND PURPOSE

Institutional context and theoretical frame

In the general education of physical sciences, it is usual to make reference to objects of the students' environment such as the electrochemical cells. Then electrochemical cell and their modeling are part of the 2002 French Chemical curriculum of Scientific Secondary School Upper Grade students (17-18 years old). The official instructions (BO) emphasize how to design effective model-based learning environments that actively involve students in their learning process. They recommend "*to simulate* [Computer simulation] *the evolution of the electrical behavior of a cell towards its balance state (discharge) by realizing many progress states of the system evolution corresponding to increasing values of the progress of reaction"*. It is in this institutional framework that the present study is registered.

Besides, the choice to use computer animation justifies itself in theory as follows: the approach of real life situations, in this case electrochemical cells, to enable students understand better, rests on the following principles: understand the functioning of a given phenomenological situation, is to represent it by a model (Halbwachs, on 1974). Modeling is the construction of a system of signs which substitutes itself to the physical situation in question and allows making operations of interpretation and forecasting (ibid). Besides, Peirce (1978), in its triadique conception of the sign, puts the iconic sign in the heart of the scientific work of conceptualisation and modeling. The physical situation in electrochemistry involves two interdependent dynamic phenomena (ohmic conduction and electrolytic conduction) and not only static structural aspects. So, the simulation of the phenomenon seems the most appropriate way of "materializing" numerically the system of signs (the model) as mobile iconic signs. It therefore ensures a function of semiotic imitation (Schaeffer, on 1999) of the imagined functioning of the electrochemical cells.

By gross simplification, we can say that simulation (computer animation) is a scrolling through the help of a computer of several images different from the plan (system of signs) of the electrochemical cells presented one after the other at different but very close instances like a cartoon. It gives the impression of a continuous progress in time of the functioning of the cell. This representational function also ensures (at least during the first steps of the approach of the phenomenon), a flashback towards its origin (the cell, the original, the imitated) (ibid). The question of the mastery of the parameters of simulation does not arise here: the students do not have the possibility to vary neither concentration, nor speed of the charge carriers, nor resistance in the circuit…). The simulation thus enables to see an invisible phenomenon with the naked eye and contributes, therefore, in its modeling. This capacity to be able to produce something to see rests in the fact that it operates a semiotic substitution of a system of signs (grade-related and symbolic) (Peirce, on 1978; Halbwachs (1974)) in the experimental, empirical device.

We suggest analyzing in what, and in which measure, the use of computer animation of an electrochemical cells can facilitate students in developing deep understanding of electrochemical concepts, and the modeling process itself in order to motivate them to learn more about chemistry.

Everyday cell versus the didactic cell

In the case of electrochemistry, where the object of study is mainly electrochemical cells, the student is found in front of a "didactic" object (fig.2a, fig.2b) different in all aspects from the view of the "everyday" object (fig.1). So, for the student, the link between both objects (didactic and everyday) is not immediate.

Indeed, for a student situated spontaneously (and often) at the empirical world (immediate perception), there is not common point between these two objects:

- The one of everyday use, is compact, in a single block (very fortunately for the convenience of its use in the everyday life), which the student ignores not only the constitution, before any lessons, but also and especially the functioning principle. This object, very practical, remains thus a real "black box", somewhere mysterious. Furthermore, it can appear under different geometrical forms, sizes and capacities, without necessarily having a proportional relationship between these three characteristics (fig.1).

Fig 1. picture of every day cell

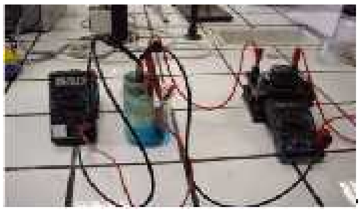


Fig 2a. Picture of didactic cell with porous wall.

Fig 2b. Picture of didactic cell with salt bridge jonction.

The other object called didactic, appears under two different forms: one constitutes of two separate vases either by the porosity of one of the vases which would then be placed in the other one, or by a porous wall, common to both vases (fig.2a). The other one constitutes of two separated beakers, a beaker containing a solution (generally solution of metallic ions (Mn^+) into which a metallic blade is inserted (the metal M), the other beaker similar to the first one, but with a different metal. For the student eyes, both beakers are interconnected by a kind of U "tube", installed upside down (!) in which there is a third solution again different from the two others (and which surprisingly could remain inside by its own without flowing in the beakers)

Each one of these didactic cells (figure 2a, 2b) is a type of macroscopic analogous model of everyday cells (figure 1); these imitations which permit to explicit its constitution and to ease understanding. In this way, the cell of fig.2b performs the same function as the cell of fig.2a, especially concerning electroneutrality. Unfortunately, they are not always presented as such. As we are going to explicit below, several researches have documented student's misconceptions concerning electrochemistry even after having received lessons (See bibliography). Most of them promote the use of simulation to build a model of the electrochemical cells. However, they have not implemented them in the same manner. There is therefore a scope to push the modeling process to a microscopic level to understand the functioning of a cell.

Difficulties in electrochemistry, and search of a remedy

The difficulties of students to understand electrochemical phenomena generally and the conduction of electric current in electrochemical cells in particular were the object of numerous research works all around the world. Several types of approaches were designed to try to understand the origins of these difficulties and to resolve them:

Garnett and Treagust (1992a, 1992b) identified indicators on the "reasoning" of students in electrochemistry by interviewing 32 students at the end of the high school cycle sector, after being taught electrochemistry. They think that "*in a solution, the electric current is due to a flow of electrons*", that "*electrons in solution are attracted by ions, and hence they move by passing from an ion to another*". Besides the problems which they have about the electric conduction, some students mistake electrodes, their polarity, as well as the name of the ions which are referred to them and the sign of the electric charge carried by them. These results were confirmed by Ogude and Bradley (on 1992, 1994) through a multiple choice question (MCQ) with 6900 students. These researches did not propose alternative didactic situations enabling to improve these conceptions and to develop them towards a satisfactory state of knowledge of the functioning of the electrochemical cell.

Based on the conceptions elaborated through previous works, Bouraoui and Chastrette (1999) led a study whose objective was to propose a remedy. For that purpose, they conducted a comparative study in Tunisia and in France on 83 high school students (16-18 years) and university students (in their second academic year in sciences) on these same phenomena. They displayed in front of the students the experimental assembly of an electrochemical cell during its functioning state, accompanied with its conventional diagram, making the link between both (a fast display of the model and the modeled object). The result of the questionnaire administered after the experiment is not convincing, and does not present a considerable evolution of the conceptions of the students to whom a misuse of the "electronic model" of conduction persists.

The limitation of the effect of this approach on the conceptions of students can be predictable. Indeed, on one hand, the diagram is already a part of the model (an iconic sign of the model), whilst its building rests with the student. Presenting students a complete diagram, is to postulate them the model and to invite them to make "the big step", difficult to realize for a learner suffering "handicaps" identified in the aforesaid researches. On the other hand, the diagram is congealed by nature; its construction does not always render "visible" a dynamic phenomenon, such as the movement of electrons and ions in the cell. We think on the contrary that it would be more relevant to make the building of the functioning cell diagram on the basis of the realized experiments, otherwise the diagram and the experimental set up would remain two worlds apart, which do not communicate between them. The multiplicity, and multiplication, of registers constitute a fundamental didactic variable in the elaboration of the models, provided that the student is involved in their construction.

Sanger and Greenbowe (on 1997, 2000), in a remedial didactic approach, opted for a display of the motionless diagram on one hand, and a dynamic numerical representation which they called computer simulation on the other hand. This experiment was done in two steps: first a display of computer simulation on the flow of electrons in metals, and then the flow of ions in aqueous solutions and the salt bridge. By proceeding in this manner, they thought that this division in time would be effective by allowing the students to focus on a single type of electric conduction once at the time to understand it better. Indeed, the students seem to have better understood the phenomenon of conduction in every type of conductor. This encouraging result shows concretely that simulation helps in the modeling of phenomena governing the functioning of an electrochemical cell. However, from their confession, these authors were a little bit surprised by the high number of still indecisive students, who manifested difficulties in associating both parts in the same continuous circuit, and thinking that electrons can flow freely in solution. If they suspect the quality of the simulation, and the short period of its display in front of the students, they do not seem to question the sequential presentation of the simulation. However, it can be a very interesting track to explore.

Besides, the eventuality of an additional difficulty which would be due to the junction by salt bridge (fig.2b) does not seem to have been explored in these researches, that is, pondering was not done on the relevance of a "model" of a cell with salt bridge in relation to a model where the junction is made by a porous wall. It is another question than we suggest dealing with in this contribution.

Following the continuity of these researches, our approach emits two main hypotheses:

The first one concerns exactly the purpose of the integrated character of the simulation of the functioning of cells, by opposition to the separated approach used by Sanger and Greenbowe (on 1997, 2000). It would be advisable then to select the most appropriate simulation for that purpose.

- The second concerns the comparison of the didactic relevance compared between both types of Daniel cells: that with the porous wall junction and that with the salt bridge junction. The second can be shown as an analogical model showing more of the flow of the charge carriers in the salt bridge.

Equipments and methods

Our equipments are two computer simulations on the functioning of cells, on one hand, and a paper questionnaire and pencil on the other hand. We were able to find, on the internet, two simulations which filled both the following conditions: (1) one of them corresponds to the didactic cell fig.2a. It is a simulation proposed by a high school teacher named Bruno HAAS (that we have indicated by the code SBH), and (2) the other one corresponds to the didactic cell fig.2b. It is a simulation proposed by university lecturers on the website of the on-line university (code: SUL).

Besides the correspondence with both didactic cells, these simulations satisfy the conditions of acceptability and accessibility developed by Tribollet and Fatet (2003) about the analysis of the numeric resources (of popularization or didactics) available on the internet.

For the experimentation, 22 students in the final year of scientific high school (17-18 years, Fr), having already followed lessons on cells with regard to the official curriculum were chosen on a voluntary basis. They thus saw the device in Fig.2b at least once. We submitted them to a pre test questionnaire, before they began viewing the simulations. Then, they were invited to watch freely on computer the simulations in question. And finally, we submitted them to the same questionnaire as the pretest, followed by a semi-directive interview on the use (their preference, impressions) on both simulations. The questionnaire is a multiple choice questions (MCQ) type. We shall explain here only the results obtained according to the abstract criteria of order and modeling. Also, we shall see the way in which the simulations were perceived by the students, as well as the effects on their reasoning.

SOME RESULTS AND DISCUSSION

According to our corpus, our results are two kinds: an analysis of the simulations in question, on one hand, and an analysis of the students' answer on the other hand.

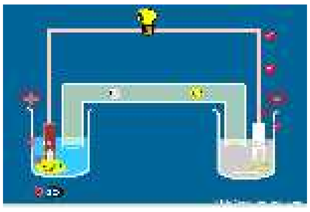
Analysis of the SBH and SUL simulations

If from the chemical point of view the electrochemical phenomenon remains the same in both types of cells (fig.2a, and fig.2b), the presence of the salt bridge seems better highlight the half-cells by separating them in space. This could, from this point of view, facilitate the understanding of the functioning of the cell.

Besides we compared the real functioning of these two cells, and verified that the presence of the salt bridge presents a major experimental inconvenience, namely the sharp increase of the internal resistance of the cell (300 times superior to that of the cell with junction by porous wall).

The SBH simulation

The SBH is elaborated in a single sequence of 36 seconds. It starts on an unanimated global plan and offers (to the chemist or the warned student) an overview of all the representative iconic signs of the functional structure of the cell (Fig.3). We also see that there is a single electron involved which flows outside the ohmic driver, parallel to it. It constitutes an abnormality in its imitative function of this conduction, not in what it badly sends backwards towards the imitated original, but in what it sends forward towards its effects (Schaeffer, on 1999) on the conceptualization of electroneutrality. Furthermore, this simulation is accompanied with no other semiotic register which could help the student to follow it without getting confused of the electric conduction.



T Fig 3 Picture of SBH computer simulation

Fig 4 Picture of SUL computer simulation

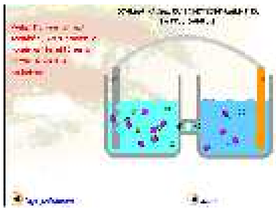


Fig 5 Picture of SUL computer simulation showing the flow of electric charges

This simulation (fig. 4 and 5) includes 55 sequences (among which 26 are animated), in 3 minutes and 23 seconds, associating observable macroscopic, such as the increase of the mass of the copper plate, the decrease of that of zinc, or still the color change of solutions, and the microscopic aspects (interpretations of the first ones) for which it is fundamentally intended.

We can blame this simulation for the absence of the interactive character of conceiving and building, which enables the student to practice and verify his own experiences.

Analysis of students' answers

The questionnaire used here is inspired by the questions formulated in the works previously quoted.

The pre-test gives, with some degree of accuracy, similar results to the researches of referenced works. For example, 40% of the students show difficulties to understand the flow of electrons and ions respectively in the ohmic conductors and the electrolytic conductors of the cell. Although the students already had a lesson on this part of their program, this results show the significance of the difficulties of students to identify the charge carriers and their respective flow sites when the cell debits. The teaching seems to have not targeted these difficulties to develop them.

It seems the free viewing of the simulation enabled to obtain a very encouraging result during post test (same questions with pre test). 80% of the students in TS (but not 100%) seem to have mastered the flow sites of the different charge carriers of electric current.

Questioned about the simulation which they prefer, the students choose without hesitation the SBH simulation. In the question "why do you choose the cell with salt bridge?" they argued that "it is clearer, we see better… the other one [that with the porous wall] is much too complicated. It takes a lot of time". Indeed, the SBH asks them for less concentration efforts because it lasts less than a minute, in a single sequence, especially since it seems to them that it presents exactly the same thing as the SUL, which is not the case. The students seem to disregard details which seem to them as secondary, such as the step of construction of the cell, and the progress of the underlying chemical reaction, in reference to the transformations of the material so simulated. Besides we could wonder if this preference is not influenced by the nature of the teaching they have already received on this subject, and where the cell with junction by salt bridge is the didactic example in the curriculum.

CONCLUSION

If the computer simulation plays an important role in the modeling of the physical situations, such as the functioning of the electrochemical cell, nevertheless its status at high school is one of a means which does not have to be confused with an objective (the modeling). The students do not participate in the construction of the simulation, which is an intellectual work of quite a different nature which could enable understand what distinguishes a model from reality of reference on one hand, and the simulation itself on the other hand.

The results of the post test are to be dealt with carefully, especially due to the pre test (which took place after the teaching of this theme) because the questionnaire was administered just after viewing the simulations. The students still thus had fresh memories filled with the images of the simulation.

But the purpose of the simulation and its effect on the development of students' conceptions remains undeniable. The students' preference of the SBH lets us think that they do not make reference only to the scientific knowledge to answer the questions. It also shows the importance of the ergonomic criteria, and other (time, the number of sequences, the neatness of the images, the size of the images, and the simplicity of the images) in the construction of a didactically effective and attractive simulation.

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A RELATIONAL MODEL OF THE LEXICON TO DESCRIBE AND ANALYSE ECOLOGICAL CONTENTS IN PRIMARY SCHOOL TEXTBOOKS

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Abstract: The importance of ecological knowledge since childhood has been well stressed out in letterature concerning pro-environmental attitudes. Although some authors underline the key role of school textbooks in the process of scientific knowledge construction, the ecological contents in schools textbooks have been poorly studied. The aim of the present work is to project a computational procedure and to develop a model of primary school textbook lexicon to describe the structural organization of the document and to detect the weight of Ecology. The computational procedure has been projected to collect, to order to archive and lastly to process the data. To test the methodology, one of the most used italian textbooks series has been worked out. The model that has been obtained is a relational one. The relational models are, infact, flexible and interactive, and allow to explore the organization of the textbooks and to detect the weight of the contents. Indeed, the model provides a representation of the semantic structure of the document so that it can be aligned with other lexical resources and ecological domain ontologies.

Keywords: Computational lexicon, Ecology, Ontology, Primary School textbook, Relational model.

INTRODUCTION

It is important to encourage the study of Ecology in the early school years, because increasing environmental knowledge may result in more positive pro-environmental attitudes (Prokop & Tunnicliffe, 2008). Many Authors underline the importance of textbooks in science teaching in primary school (Chiappetta, Fillman & Sethna, 1991; Korfiatis, Stamou & Paraskevopoulos, 2004) for both teachers (Stern & Roseman, 2004) and students (Caravita, Margnelli, Valente & Luzi, 2007; Caravita et al., 2008). However, some Authors (Korfiatis et al., 2004; Caravita et al. 2007; Gambini, Pezzotti & Broglia, 2008) point out that Ecology is poorly represented in schools textbooks. During primary education, pupils are expected to develop increasingly more complex and systemic ideas about the living beings and their environment. Particularly, the italian curriculum for primary fifth grade includes aspects concerning biological systems and environmental systems such as ecosystems, their biotic and abiotic characteristics, the way human being can protect environment (Ministero della Pubblica Istruzione, 2007). It is than interesting to assess the real alignment of ecological contents of textbook and italian school curriculum.

The content analysis of textual documents require the use of methods to single out the useful features found in the text (Feldman & Sanger, 2007). Moreover, the development of a model is a necessary process when working in computer environment, since just a model enables to maintain the dynamism inherent in the linguistic-textual system of a document (Orlandi, 2010).

The relational approach tries to make explicit the structural organization of a document, which is implicit in models of other approaches, and describes how the terms extracted from texts are related to each other (Evens, 1988). Furthermore, as the conceptualization of basic ecological concepts and processes is an essential requirement in order to come to understand more complex ecological subjects of study, this approach allows to assess the exposure of children to ecological knowledge during the all five years of primary school. For this reason the content analysis of textual documents requires a flexible representation models for the assessment of contents of interest through the texts (Feldman & Sanger, 2007) as through the school time.

PURPOSE

The aim of the present work is to project a computational procedure and to develop a model of primary school textbook lexicon to describe the structural organization of the document and to detect the weight of Ecology.

MATERIAL AND METHOD

In order to assess the procedure, it has been processed one of the most used italian textbooks series, published by Giunti. Five books, one for each school grade have been analyzed, considering Geography, History and Science sections, for a total of 661 pages.
Each textbook is organized into well distinct and hierarchically nested structural parts (hereafter Visual Blocks or VBs). Main VBs are represented by thematic sections, each divided into chapters, and these subdivided into paragraphs that are associated with the paratext VBs, such as boxes, pictures and insets. The paratext is important from the standpoint of learning as they give the student the opportunity to study in-depth and to check understanding. Every VB is thematically homogeneous. It is also important to stress that the terms of subject content, considered important by the Author (hereafter Relevant Terms or RTs) are highlighted by special fonts in both text and schemes. Each textbooks series results from editorial decisions on the layout and organization of information. Despite this diversity, it is possible to trace the variety of VBs of the different textbooks series at a general VB types taxonomy. The detection of RTs is implemented in the model as the representation of the content of a textbook. The VB types taxonomy is intended to provide criteria for the classification of VBs. The lexical relations between the RTs contained in VBs are inferred based on the hierarchical relationships between VBs.

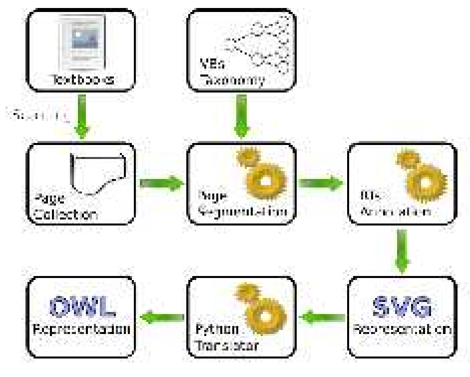

Figure 1. The computational process.

The Figure 1 illustrates a diagram representative of the computational procedure. The process is interactive and requires the intervention of a human agent. The book pages are scanned and raster images produced are collected in an archive. Each page is split up into constituent VBs

through visual segmentation. To this end, each VB is recognized by its distinctive characteristics and classified with reference to the VB types taxonomy. Every VB identified is annotated with the RTs that are contained in it.
Page segmentation and RTs annotation are performed with a vector graphics editor like Inkscape (http://inkscape.org), which is based on the W3C SVG, derived from the XML. A page raster image is imported into the software user interface, and every VB is bounded by a polygon that the software automatically translates into XML. Then, using the XML editor integrated in Inkscape, the VBs are annotated typing the respective RTs in. The lexical relation between the terms are defined with the RTs annotation. The RTs of a higher order VB subsume the RTs of the lower order VBs. This rule generates a tree structure of the RTs of the page. The annotated SVG file is then processed with an *ad hoc* Python (http://www.python.org) script, which implements an XML parser, which can combine RTs trees of different pages and can optionally translates outcomes in OWL format, a standard ontology modelling language of the World WideWeb Consortium (http://www.w3.org/).
The combination of different RTs trees is done through identification and connection of equal RTs. The result is a directed graph where each node is represented by a distinctive RT and edges depend on how the pages have been segmented. This structure is analyzed using measures rooted in graph theory (Bang-Jensen & Gutin, 2007). With these measures, the general organization of each graph and the topological properties of individual concepts are detected.

RESULTS

The graph obtained consists in 2009 nodes and 4816 edges and has a diameter of 8 connections.
Ecology, for example, explicitly appears only once and has a node degree of 1. Moreover, *Ecology* has an eccentricity of 7 and a diameter of 8.
Figure 2 shows a RTs tree resulting from segmentation process of a page in the Giunti Scuola textbooks series.

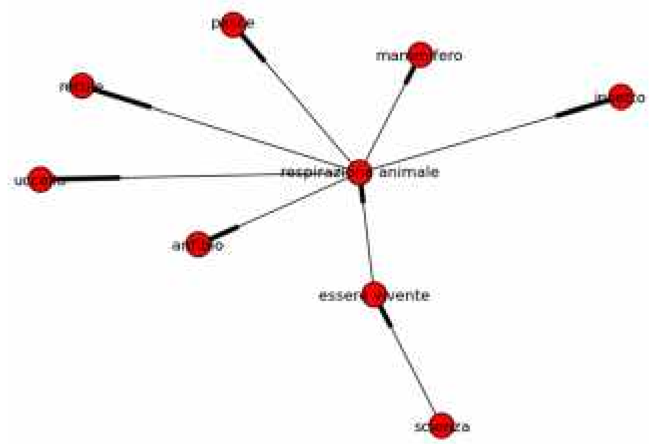

Figure 2. An RTs tree.

Figure 3 shows the graph obtained by the combination of the RTs tree of Figure 2 with the RTs tree of the following page. The two original trees have in common the RTs of the section title, “scienza” (*science*), the chapter title, “essere vivente” (*living being*), and a group of terms including “scheletro” (*skeleton*), “invertebrato” (*invertebrate*), etc.

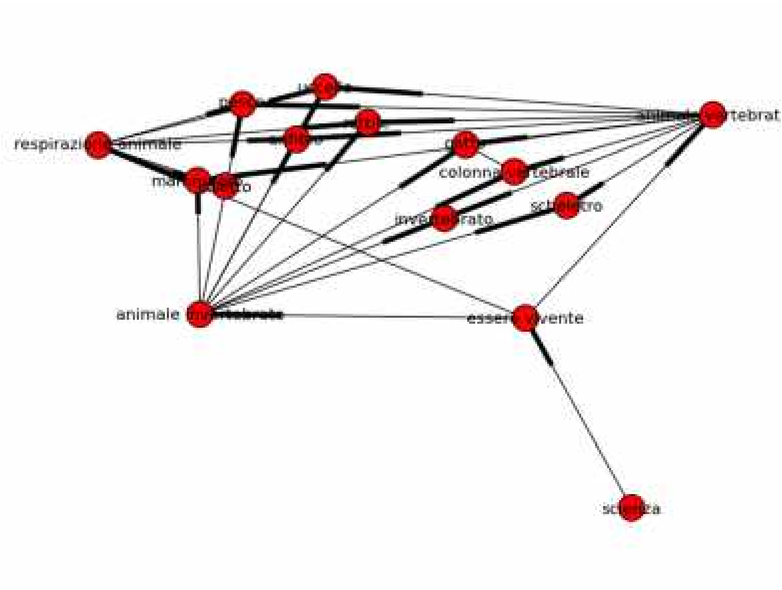

Figure 3. Graph resulting from the combination of two RTs tree .

Combining RTs trees sequentially and orderly, it is possible to analize the evolution of each graph measure with the flow of pages. For example, Figure 4 shows the evolution of graph diameter (by definition, the smallest of all shortest path lengths of the graph) resulting from the gradual combination of the pages, from the first page of first year textbook until the last page of the fifth year textbook. Similarly, Figure 5 illustrates the evolution of the eccentricity of the two terms “animale” (*animal*) and “pianta” (*plant*).

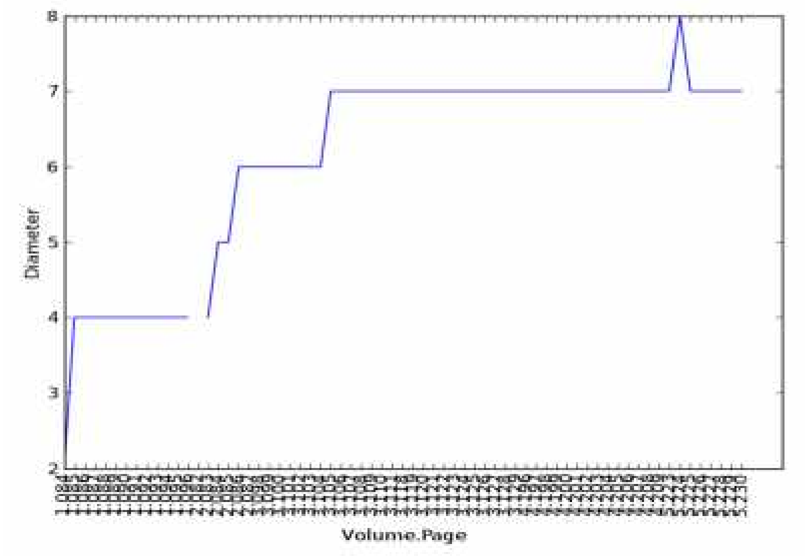

Figure 4. Graph diameter evolution.

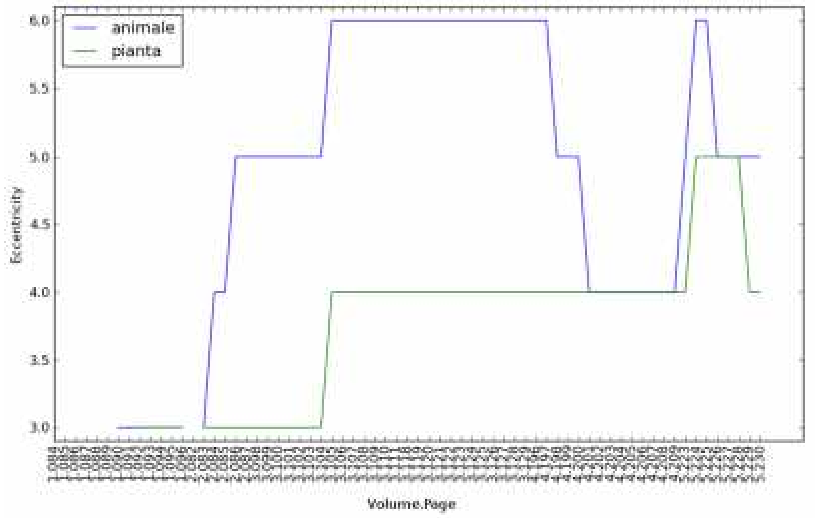

Figure 5. Evolution of eccentricities of the "animal" and "plant" nodes.

DISCUSSION AND CONCLUSION

The model seems to be suitable to describe the structural organization of the textbooks and to detect the weight of Ecology within them. Therefore, it allows to assess the children's exposure to ecological concepts during the five primary school years.

Furthermore, the analysis of the network at every stage of its evolution allows to evaluate when and how ecological concepts are introduced and their progressive differentiation. This offers interesting pedagogical interpretations analizing different disciplines presented into the same textbook and comparing different textbook series. The model is also flexible and can be aligned with ecological domain ontologies (Thiagarajan, Manjunath & Stomptner, 2008; Prèvot, Borgo & Oltramari, 2010) This will allow to measure the distances between the ecological contents detected and a more general ecological domain. Our current research is proceeding also forward the application of the relational model to obtain semantic relatedness measures that can be assessed in a pedagogical point of view.

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DEVELOPMENT AND EVALUATION OF A DIGITAL ENVIRONMENTAL LEARNING GAME FOR CHILDREN

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Abstract: This research described the development of the Vegetation Interaction Game, a new digital game on the theme of vegetation succession. An evaluation experiment targeting elementary school students was conducted in order to verify the efficacy of this game as a learning-aid tool. The results of the knowledge and understanding test, a survey on the degree of immersion and a survey on the user-friendliness of the interface revealed that this game (1) supported children in their knowledge acquisition and understanding of vegetation succession, (2) helped children become immersed, and (3) provided children with a user interface that could be understood easily.

Keywords: Digital game, Vegetation succession, Role play, Elementary school, Environmental learning

BACKGROUND AND THEORETICAL FRAMEWORK

In science education, digital games have become one of the more effective learning tools. In such a learning environment, a learner can acquire scientific knowledge through the process of role-playing in the game. For example, simulation in a game can reveal the phenomena and processes of the microscopic motions of atoms and molecules, as well as macroscopic movements, and large temporal-scale phenomena.

Clark et al. (2009) reviewed preceding studies on digital learning-aid games in order to verify the efficacy of this game as a learning-aid tool. According to this review, major characteristics of such games included the players becoming immersed in the game by entering the character of the game, acquiring new knowledge as the game progresses, or applying the acquired knowledge as the game unfolds. Many digital games have been developed as learning aids in science education (for example, Barab & Dede, 2007; Collera, 2000; Dede, 2009). However, a game themed on vegetation succession in forests did not previously exist.

In this study, we developed a new digital game themed on vegetation succession. Vegetation succession is a phenomenon wherein the numbers and types of plants in a forest undergo transition during a certain time period. This phenomenon occurs largely due to substantial disturbances such as tree cutting or landslides, and interactions between certain types of plants in the forest. It takes many years to complete one succession. A digital game themed on vegetation succession appears to be very useful for students to understand such large temporal-scale phenomena.

PURPOSE OF THE STUDY

The aim of this research was to develop the Vegetation Interaction Game, a new game themed on vegetation succession, and to evaluate its efficacy. This game employs the role-playing board game format where each player is represented by a token and the game progresses by advancing these tokens along the squares on the board. The player that advances his/her token the most wins the game. An evaluation experiment targeting elementary school students was conducted in order to verify the efficacy of this game. The following three questions were posed in this research:

(1) Does the Vegetation Interaction Game support children in understanding vegetation succession?

(2) Is the Vegetation Interaction Game something children can become immersed?

(3) Is the interface of the Vegetation Interaction Game easy to understand for children?

DEVELOPMENT OF THE VEGETATION INTERACTION GAME

The Vegetation Interaction Game represents what a real vegetation succession looks like. A phytosociologist who is an expert on the Mt. Rokko area in the western Japan was the principal consultant of this game. Figure 1 shows the main window of the digital game. Six pieces represent six characteristic plants that grow in the Mt. Rokko region. The six plants include two early succession plants, Red small berry (*Rubus microphyllus* L. fil.) and Japanese Mallotus (*Mallotus japonicus* (Thunb. ex Murray) Mueller-Arg.); two middle succession plants, Red Pine (*Pinus densiflora* Sieb. et Zucc.) and Quercus oak (*Quercus serrata Thunb.* ex. Muuray); and two late succession plants, Longstalk holly (*Ilex pedunculosa* Miq.) and Castanopsis evergreen oak (*Castanopsis sieboldii* (Makino) Hatusima ex Yamazaki et Masiba). The central part of main window houses the following components of the game: a deck of event cards (Fig. 1-a) and a visualization screen to show vegetation succession according to the progress of the game (Fig. 1-b). Players can switch this vegetation succession visualization screen to show only one plant to focus on that plant.

If more than one piece takes the same position on the grid, the competitiveness for the light is either strong or poor between the plants; that is, the ‘interaction’ between the plants, as shown in Fig. 2. We set the event cards to correspond to types of disturbances that could possibly occur in the Mt. Rokko region. There are six such event cards: two large disturbances—tree cutting, landslide; two small disturbances—wild boar and pine longicorn-nematode disease; and no disturbances—fair weather and rain. These events influence vegetation succession.

Six players can participate in any one game. Each player handles one piece. Players draw event cards, one at a time, by clicking the event cards in turn. When a plant piece advances ahead on the board grids, it implies that the plant is dominant in that particular environment. Each piece moves according to the number of grids that the current event card indicates or if there is an interaction between the plants. The game finishes when all event cards are drawn.

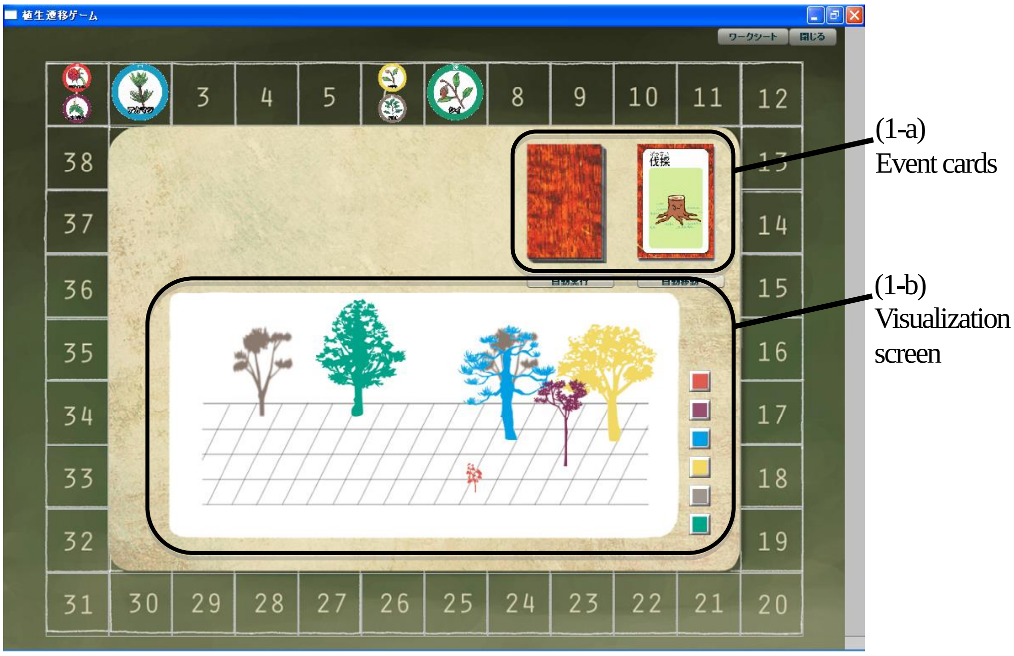

Fig 1. Main Window

Fig 2. Interaction between plants

EVALUATION OF THE GAME: RESEARCH DESIGN AND METHODOLOGY

Knowledge and understanding test

A knowledge and understanding test on the same topics was administered to 36 children before and after they played the game. The test consisted of a total of 18 questions on the understanding of 'influence of disturbances' and 'interaction among plants'; both the pre-test and the post-test were graded out of a maximum score of 18.

Survey on the degree of immersion

A survey on the degree of immersion was conducted using questionnaires targeting 36 children. There were a total of 16 questions and children were asked to choose one of four levels of responses for each question.

Survey on the degree of user-friendliness

A survey on the degree of user-friendliness targeted 17 randomly selected children. The two questions were 'was the visualization screen of the interface easy to understand?' and 'was the interaction among plants easy to understand?' Approximately 10 minutes were spent on each child. In the analysis, the numbers of 'children who gave only positive answers,' 'children who gave both positive and negative answers,' 'children who gave only negative answers,' and 'children who did not answer' were counted for each question.

DATA ANALYSIS AND RESEARCH FINDINGS

Knowledge and understanding test

The average scores were 5.00 (standard deviation 2.63) for the pre-test, and 11.47 (standard deviation 2.31) for the post-test. Using the Wilcoxon signed-rank test, it was revealed that the post-test yielded significantly higher scores (z=-5.14, p<.01).

Survey on the degree of immersion

Table 1 shows the result of the survey on the degree of immersion. 'Definitely' and 'I think so' were considered positive answers, and 'Not really' and 'Definitely not' were considered negative answers. Fisher's exact test (1 by 2) was conducted in order to examine the answer trends. The results revealed that the number of positive answers exceeded the number of negative answers in every question .

Game Interview

'Children who gave only positive answers' and other children were tallied and Fisher's exact test (1 by 2) was conducted in order to examine the answer trends of the children. The results revealed that the number of 'children who gave only positive answers' significantly exceeded the number of all other children.

Table 1. Results of survey on the degree of immersion

Questions	Definitely	I think so	Not really	Definitely not
1. The game was fun to play.**	35	1	0	0
2. I want to play the game again.**	32	3	1	0
3. I was immersed in playing the game.**	29	6	1	0
4. I was excited in playing the game.**	32	3	1	0
5. I felt like I was the plant.**	9	22	4	1
6. I understand the influence of disturbances well.**	17	18	1	0
7. I understand the interaction among the plants well.**	15	19	2	0
8. I watched the balance of power relationship between the plants when the interaction	28	7	1	0

happened. **				
9. I understand the power relationship between the plants immediately when the interaction happened. **	18	16	2	0
10. I thought a lot about the increase/decrease in the number of plants when the interaction happened. **	11	19	6	0
11. I discussed a lot with group members when the interaction happened.*	6	20	9	1
12. I watched the vegetation succession visualization screen during a game.**	27	7	2	0
13. I switched the vegetation succession visualization screen to show only my plants.**	20	7	6	3
14. I understand the increase/decrease in the number of plants immediately when I watch the vegetation succession visualization screen. **	25	9	2	0
15. I could imagine actual vegetation succession from the vegetation succession visualization screen.**	12	20	4	0
16. I discussed a lot with group members when I watched the vegetation succession visualization screen.**	9	23	4	0

N=36. $^{**}p$<.01, $^{*}p$<.05.

CONCLUSIONS AND IMPLICATIONS

This research was used to develop the Vegetation Interaction Game using vegetation succession as the theme. Further, a demonstration experiment was conducted at an elementary school in order to verify the efficacy of the game. Three tests/surveys concluded that the Vegetation Interaction Game, as a learning-aid tool for science education, possesses the digital-game characteristic of immersing the players in the game while supporting their knowledge acquisition and understanding of the scientific phenomenon of vegetation succession. Clark et al. (2009) mentioned that the effectiveness of digital games in supporting children's learning is that games have rules and goals that encourage children's becoming immersed in the game and simulations that accelerate children to imagine macro/microscopic, or large temporal-scale scientific phenomena. It can be said that the Vegetation Interaction Game developed in this study is effective in supporting children's learning of role-playing and visualization screens.

This research succeeded in developing a new digital game that supports science education, themed on an unprecedented topic of the scientific phenomenon known as vegetation succession. Vegetation succession is a phenomenon where the species and number of dominating plants change within a certain forest environment. In this day and age, where harmonious coexistence of mankind and nature is a major goal, it is important to provide children the opportunity to understand and gain first-hand experience of the vegetation succession in forests through science education. The implication of this research is that digital games can be effective tools for supporting the learning of these types of phenomena.

NOTES

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TRANSPOSITION OF A SCIENTIFIC TOOL INTO THE EDUCATIONAL WORLD: THE CASE OF MOLECULAR VISUALIZATION

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Abstract: Molecular visualization (MV) software enable a user to view a molecular model via a computer. They are regularly used by researchers in biology in many ways and the willingness on the behalf of the institution was strong to very quickly integrate the MV software in biology education.
Our work here focuses on the transposition of a scientific tool, the MV software, in the educational world and specifically on their use with students. It is relevant to study their conception and use in the classroom because several studies have shown that they can improve the understanding of molecular concepts among learners.
In order to study this use, we employed three types of indirect approaches, analysis of the francophone web, analysis of textbooks from three editors since 1992 and analysis of interviews conducted with five French biology teachers who use MV software.
The results obtained by these three approaches converge and indicate that there has been the production of a scholar tool from a scientific tool. More specifically, we observe that almost only one software is used, some molecules related to this software and some activities designed using this software and these molecules. However these activities remain illustrative whereas one might have expected some of them to enhance an investigation posture. Furthermore, the origin and status of molecular models are not or very little explained. And this may lead the students to a misconception of the molecular models.

Keywords: Biology education, ICT, molecular model, use of molecular visualization software

BACKGROUND, FRAMEWORK, AND PURPOSE

In the teaching of biology, in the early 1990's, there was a willingness of the institution to be as close as possible to the scientific techniques developed in laboratories [Demounem 1992].

Our framework is based on the idea developed by Martinand (1989) that the academic discipline refers to social out of academic discipline defined as "social practical of references" and particularly scientific practice for science education. We are also study how the computerization of a discipline works, a field described by Linn in 2003.

Here we are going to investigate the result of the transposition of a scientific tool into the educational world. For that, we are going to focus on the case of molecular visualization (MV).

In the early 1950s, biologists realized the first models of biological macromolecules. Knowing the structure of these macromolecules represents a significant challenge given their small size, we understand it is necessary to use various experimental techniques (such as X-ray crystallography) to get information on the molecule and thus build up a model (see figure 1). The first models were visualized using large physical models (several meters). But it's in 1966 that Cyrus Levinthal and his team [Levinthal 66] realized the first MV through a computer. Subsequently, the software and computers have improved and, in 1993, *RasMol*, a MV software able to run on a personal computer, is put into the public domain which has brought this technology formerly restricted to a few research centers at the door (financially speaking) of all. For further details on the historic of MV, see Matz & Francoeur (2010).

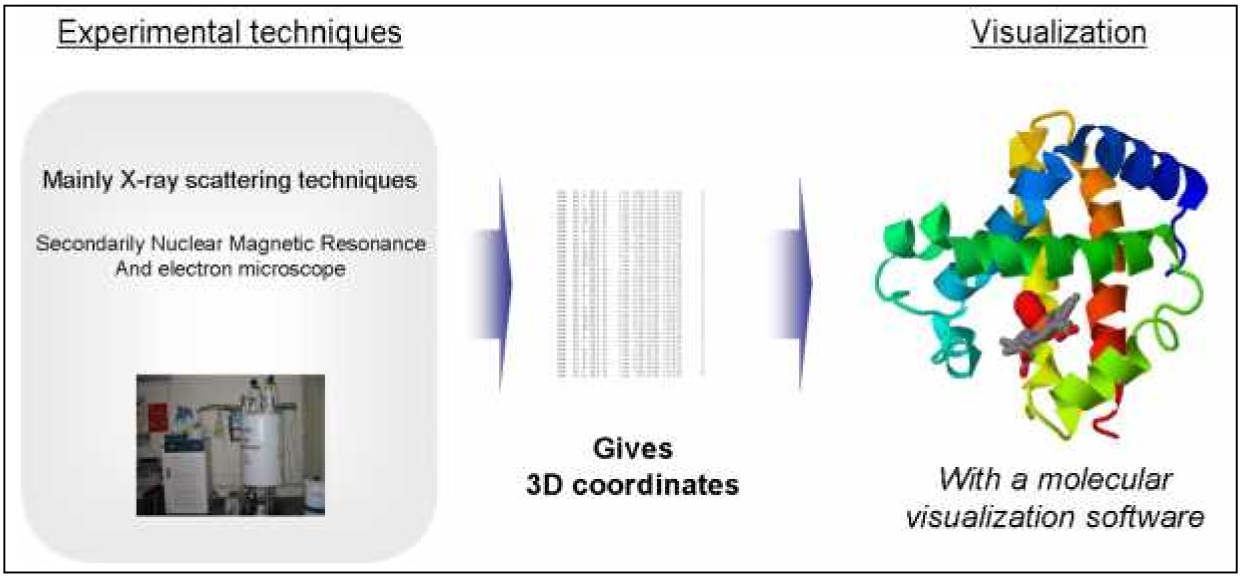

Figure 1: Way of obtaining a 3D model of a molecule.
And a representation that can be observed with a molecular visualization software.

Today, the MV represents a major challenge in biology given the importance of knowing the structure of molecules. Indeed, the structure of biological macromolecules dictates their functions, that's why the MV is used in many parts of biology as [Watson & al. 09] retail it. They are eg used by every researcher who wishes to produce an image of the molecule(s) he studies to illustrate his point in an article.

Martz, professor emeritus at the MIT, greatly encourages the use of MV software in education through his website [Matz, 10] that may be the biggest website for MV resources for teaching purpose. In France, analysis of the national curriculum of "sciences de la vie et de la terre" (SVT), the equivalent of biology and geology, indicates that MV is tucked into this curriculum with a recommended use of MV software for some practical work. In scientific 11th grade (16 years old), as early as the 1993-1994 school year, that is to say as soon as the MV software was available to the general public and, in scientific 12th grade (17 years old), from the year 2000 and, for 10th grade (15 years old), in 2010. Furthermore, these MV software figure in the test to graduate from high school through the evaluation of experimental capacity in SVT, being present in approximately 10 % of the subjects offered.

The work presented here is part of a PhD interested by the transposition of a scientific tool, the MV software, into the educational world.

RATIONALE

As Yarden and Yarden (2009) show it with the use of a PCR animation as a visualization tool, the animated tool provides “a significant advantage to the students who used it over those who used still images”. So animations can facilitate the comprehension of molecular processes.

Ferk, Vrtacnik, Blejec and Grill (2003) show on students from 13 to 25 that, on one hand, they have a better understanding of molecular models with representations on computer software with a MV software than with a 2D representation with a photograph or a schematic representation of molecular model. On the other hand, the correct perception of the 3D structure of the molecule is crucial for all subsequent mental operations related to molecular structures.

In the same vein, Berry and Baker (2010) show that “it is often extremely difficult to impart an understanding of complex three-dimensional relationships when using two-dimensional projection screens” and therefore molecular visualization software make “it possible to bring spatial relationships to life with three-dimensional images”.

These studies thus show that MV software can be beneficial to the teaching of molecular concepts; therefore it is relevant to observe how the software is used in high school during SVT courses.

METHODS

It is difficult to get information on the use of software in the educational system in France. Indeed, there are no organisms or reports that gather information on this topic. That’s why we had to use indirect approaches to get an idea of the result of the transposition of MV software in high schools in biology in France.

First we assumed that there would be some marks of this use on the French web. That’s why we investigated it to find some hints that would show the use that can be done with MV software. We started to analyze the websites that are supposed to help teachers. These websites are the 35 academic sites (an academy is an administrative district of the French minister of national education, each one has is its own website with several resources for the teachers) and the site of the “National Institute for Educational Research” (INRP) through the section managed by the team of “Continuous Updating of Knowledge of Science Teachers” (ACCES) [ACCES 10]. And after, we used the search engine *Google* to find other websites that could give us some more information.

Second we analyzed textbooks of five different publishers (Bordas, Hatier, Nathan, Magnard and Hachette) from 1992 to 2010. Indeed, textbooks are very often used by French teachers to give their lessons.

Finally, we conducted interviews with six French high school (grade 10, 11 and 12 – age 15 to 18) SVT teachers known to be expert in the use of MV software. The questions asked aimed at knowing which molecular visualization software they used and why. How they discovered the software. The activities they have done with the software. The problems they face when using the software. And the possible improvement they could feel when using the software.

RESULTS

Analysis of the francophone web

The analysis of the francophone web showed that beside the academic sites and the site of the “National Institute for Educational Research” (INRP), information about MV software for teaching is not or barely not on other French websites.

On academic sites, the most often emphasized MV software is *RasTop* that was created in 1996 from *RasMol* in order to be adapted to the educational world. It is possible to find, on some academic website, activities using MV software intended to be made during practical work to introduce molecular concepts (like the structure of DNA). But they almost all refer to the section ACCES of the website of the INRP.

On the ACCES section, there are many information about the *RasTop* software: a fairly complete description of the software, molecules to download and examples of possible activities with this software. It also contains information on *RasMol* but far less significant.

We can also notice “Library of Molecules” website [Librairie de Molécules 10], a cooperative site, in which 11 academies participate, which provides molecular models selected by teachers for a classroom use. Nevertheless, website activity so far remains low.

There is thus, on the French web, a key role played by the ACCES section. With a focus on one software, *RasTop*, a pool of molecules available which has slightly varied from the one proposed by ACCES in the early 2000s and a small number of activities that also have slightly varied from the early 2000s. There is only a few opening on the English websites like the site of the *Protein Data Bank* (PDB) website which is the single worldwide repository of information about the 3D structures of large biological molecules. These results were reinforced by an analysis of user queries on the *Google* search engine and user requests to access to the site of the INRP (Author and Blondel, 2011). Finally it is important to note that, nowhere on the French web, the origin of molecular models and how to obtain them is questioned.

Analysis of textbooks

The textbook analyses showed that the images of molecular models presented are not or barely not exploitable because of the lack of precise data (no caption, unspecified representation, no scale, etc.). Some textbooks also offer activities similar to those offered on the web francophone. Finally, in the same way as on the francophone web, neither the origin of molecular models nor its status is explained. So the textbooks are insufficient in themselves to address the MV.

There is also an evolution during time, in the latest textbooks there are a bit more topics related to molecular visualization software. And there is the emergence of technical sheets on *RasTop* in the most recent textbooks.

Analysis of the interviews with the teachers

The analysis of the interviews with the teachers showed that they use the *RasTop* software during practical work to realize activities such as those described on the francophone web. They say they spend little time on the explanation of molecular models. They indicate that these molecular models are not always very clear for the students who may sometimes feel like observing a molecule and not observing a model constructed by scientists.

Question: Do students clearly understand the conception of molecular model?

Teacher: I am not sure, I am not sure at all, for example sometimes they believe that they are watching a real molecule in real-time and not a model…

Teachers indicate they regret the lack of molecules and examples available to use MV software.

CONCLUSIONS AND IMPLICATIONS

All the results obtained with the different approaches converge to say that there has been fabrication of a scholar tool with a reduction phenomenon on one software (*RasTop*), mainly one website (the section ACCES of the website of the INRP), few molecules and some activities. In addition, these activities remain illustrative whereas one might have expected some of them to enhance an investigation posture. And it seems that since 2002, the school practices are stabilized and did not change a lot.

Furthermore, it is important to note that the origin and status of molecular models are not or very little explained. Perhaps this leads to a misconception from the students about the molecular models as indicated in the speech of teachers. As Linn (2003) suggests it, perhaps visualizations confuse rather than inform learners.

PERSPECTIVES

It could be possible to study the “social practical of references” to propose some new activity that could renew the use of these software in classes. And thus design new activities with the collaboration of teachers.

We might also consider studying how molecular visualization is used in education in other countries, for example in the US.

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COHERENCE OF AN ICT-USING TEACHING SEQUENCE: A CASE STUDY IN OPTICS AT LOWER SECONDARY SCHOOL

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Abstract: This communication reports a case study based on a discourse analysis in an ordinary classroom, at grade 8 in a lower-secondary school in France, during a teaching sequence in elementary Optics. It particularly focuses on a part of the last session, where the eye is presented as an optical system using a lens, the focal length of which is variable. For this part, the teacher is using a computer-based simulation. The teacher's discourse is analysed from a threefold point of view: the modelling processes; the conversions between several semiotic registers; the coherence between this session and previous activities in the teaching sequence. From all these points of views, the use of an ICT tool offers new learning opportunities to students, or strengthens learning opportunities already offered.

Keywords: ICT, Coherence, semiotic representations, modelling processes, affordance.

1. INTRODUCTION

ICT-based tools have reached a high level of use in science teaching in developed countries; they have multiple uses (among different typologies, see for example Pinto and col., 2010). This use can be seen and studied more specifically, for instance when an ICT-based device is chosen by the teacher to fulfil a specified task, at a given moment of a teaching sequence. As far as students' learning is taken into consideration, the long-scale effects that is, the coherence of the ICT use regarding the other parts of the teaching sequence, must be analysed as well: what is the role of an ICT device in a teaching sequence? Is it used to introduce new notions or to reinforce concepts that have already been studied?

The theoretical tools that we shall use in this case study take into account the multimodal dimension in science teaching and divide among three elements: the modelling processes, the semiotic registers and the affordances or learning opportunities.

2. THEORETICAL FRAMEWORK

2.1. Modelling processes

Models and modelling are an essential dimension in science teaching. Tiberghien (1994) distinguishes between two worlds in teaching/learning physics. She defines:
- the world of objects / events as knowledge elements that refer to the observable and material world,
- the world of models or theories, as qualitative or quantitative notions and procedures that correspond to the generalizable aspects of the studied situation.

From this epistemological point of view, physics teaching can be considered fundamentally as a matter of modelling processes, of establishing meaningful links between “the world of objects and events” and “the world of theories and models”.
Very often, ICT-based tools represent models of empirical realities, and one of the tasks of the teacher is to make this status clear for the students. For instance, in our case, the software used in physics (Cabri-Géomètre[1]) obeys the rules of physics and its representations belong to the world of theories / models.

2.2. Semiotic registers (semiotic representations)

Science classroom discourse is a particular one. It is multimodal in principle (Lemke, 1998) and uses several semiotic registers. Duval (1995) defines the semiotic registers in the following way: "they are the productions made by the use of signs (utterances in natural language, algebraic formulas, graphs, geometrical figures…)".

When using ICT in science classroom, many modes of representation, many “semiotic register” are used in the classroom discourse; the dynamic graphical representations, which are the core of most ICT-based tools, must be articulated with natural language (words and gestures as well), or static graphical representations (drawings or schemas on the blackboard, for example), or mathematical symbolism.

Duval defines some semiotics registers in mathematics education. We take in the following semiotic registers very often used in teaching physics:

- The register of natural language: it is the primary tool used before and / or during the acquisition of scientific vocabulary. This register is flexible that is, used in the world of objects / events, the world of theories / models and to make a link between the two worlds.

- The register that contains drawings, diagrams, and graphs:

a- a drawing is an "exact representation of the shape of an object" (Davy & Doulin, 1991);

b- a schema is a representation of a referent. It can be non-figurative and figurative. A figurative schema refers to something sensible, visual and perceived while a non-figurative schema designates a mental referent. (Estivales, 2003, page 56).

2.3. Affordance versus Learning opportunity

The psychologist James Gibson proposed the term “affordance”, in his ecological theory of perception (Gibson, 1979). He noted that the affordance depends on interactions between the animal and its environment: “*affordances as what the environment offers the organism”*.

In the field of ICT-based science education, Webb (2005) expresses a definition for the notion of affordance inherited from Gibson: “*In an ICT-supported learning environment affordances are provided by interactions between the hardware, software, other resources, teachers and other students*” (Webb 2005, p.707).

We consider as meaningful to introduce a distinction between two phases of teacher’s activity when implementing an ICT-based activity in the class, regarding the coherence of the teaching sequence and the effects on learning. This distinction is a consequence of our socio-cultural point of view on science learning, which gives a key role to social interactions in the construction of knowledge.

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[1] www.cabri.com

When a teacher plans to use an ICT-based tool in a teaching session, he or she first chooses the software (or special functionalities of the software), depending on the school equipment, on the starting point of the students, on the teaching aims, etc. The teacher also foresees the way he or she will play the scene. We keep the term "affordances" for this set of characteristics that are planned before the session begins.

During the activity itself in the class, the interactions can widely modify what has been planned. When we analyse the classroom discourse, we find evidences of unpredicted suggestions by students, or unforeseen procedures (right or wrong) they use, which deviates the knowledge flow in the classroom discourse and activity, and consequently which can activate or inhibit previously organized affordances. We call *learning opportunities* the affordances that have been effectively offered to students during the classroom interactions; students can catch or not these opportunities, this is another question asking for different methodologies.

2.4. Links between the theoretical tools

These four kinds of theoretical tools are relevant with our purpose to analyse the coherence between the moments when the teacher uses ICT-based activities, and other moments of the sequence. These two kinds of activities can be at different modelling levels, on one hand, and use different types of representations on the other hand. Moreover, the term of affordance, as defined by Webb in the cited sentence, is essentially an integrated one, insisting on the various facets that constitute an affordance.

3. RESEARCH QUESTION

Taking into account the previous theoretical elements, the questions in this study are: how does the use by the teacher of an ICT-based tool construct the coherence of a teaching sequence? How does the use by the teacher of an ICT-based tool offer new learning opportunities to students, in the flow of classroom discourse?

4. METHODOLOGY

We have filmed a male physics teacher at the lower secondary school in France, during a complete teaching sequence. This sequence consists in six activities, each session lasting one hour and a half. This sequence[2] is a research-based one, as it has been elaborated in a joint group involving a researcher and several teachers.

We have indexed our video data of the entire sequence in a table (script). We identify the sessions where the teacher used the software Cabri in the sequence: two times. We have chosen to present here the analysis of a single use of Cabri (the second one, May 25).

We particularly looked at the moments when the teacher used the software, and we transcribed these moments. In the discourse of the teacher we searched all the indicators relating to the activities earlier in the sequence.

We present below (table 1) the "script" of the sequence including moments where the teacher used the software.

Date of the	Number of the activity	Learning objective indicated at the beginning of each activity	Content of the activity

[2] See the current version at http://pegase.inrp.fr/theme.php?rubrique=1&id_theme=57

session			
2010_04_06	Activity 1 Activity 2	1. Recognize the different types of lenses. 2. Understand the effects of a converging lens in terms of optics.	1. The students work in pairs to find among four lenses, which of them can serve as a magnifying glass. The strategy consists in looking through the lenses. 2. The teacher introduces the terms *diverging* and *converging* lenses.
2010_05_11	Cabri (addition)		*Modelling a converging/diverging beam of light after passing through a converging/diverging lens.*
	Activity 3	3. Show that the energy is concentrated at the focus of the converging lens for sources situated at the infinite.	3. The students carry out experiments using a thermometer, a converging lens, a screen and a lamp. Students place the lamp as a light source followed by a converging lens. They measure the temperature of the light spot formed on a screen as they move it from the lens.
2010_05_18	Activity 4 Activity 5	4. Show that some specified condition is necessary to obtain an image . 5. Understand the vision mechanism from the point of view of optics.	4. The students send the light of the lamp on a slide with the letter P. The light passes through a fixed converging lens. Students move the screen (backwards and forwards from the lens) to obtain an image. 5. The students establish the correspondence between the terms mentioned in the drawing of the eye (figure 1) and the following words in the text: diaphragm, converging lens and screen.
2010_05-25	**Cabri (addition)**		*Correspondence between the elements of the eye in a schema and a drawing.* *Convergence of the rays passing through a lens when they come from an object at a finite distance or an infinite one.* *Explanation of the accommodation phenomenon.*
	Activity 6	6. The corrective lenses for the eye defects.	6. Correction of eye defects.

Table 1: Script of the sequence titled "lens" (grade 8). The use of Cabri-files that has been analysed took place on May 25 (bold characters).

It was not planned to use Cabri-Géomètre in the sequence. That is why we have not completed the learning objective on the corresponding lines. The teacher was proposed to use Cabri files in this sequence by one of the authors, as they may facilitate the understanding of the modelling processes by the students.

5. ANALYSIS

We present the results of analysis according to each theoretical framework.

5.1. Analysis in terms of modelling processes

5.1.a. <u>Analysis of the files realised under Cabri Geomètre</u>

Cabri was used to model the convergence of light rays after passing through a converging lens. On this file, the teacher has the possibility to choose and modify the location of the object (finite distance, infinite distance) from the lens.

These Cabri files obey to the laws of Optics, and the representation obtained by Cabri refer to the world of theories / models.

Nevertheless there is a difference between the kind of representation adopted by the Cabri-files and the conventional representational rules of Optics: in Cabri-files rays are represented by lines without arrows, when optical rays carry arrows to indicate the direction of light propagation.

5.1.b. <u>Teacher's discourse analysis during the session</u>

The teacher's discourse allows us hypothesising that the teacher aimed at making a link between the two worlds. We base this interpretation on the observed identification of some elements of the world of objects and events (the crystalline lens, the pupil, the retina, all specified by the "drawing", figure 1) to corresponding elements of the world of theories and models: the lens, the opening in the square, the screen on the bottom of the square (figure 2).

In his discourse, the teacher tried to explain a phenomenon of everyday life (the accommodation) through a physical model. He suggested the situation belonging to the world of objects / events for students ("*Probably you noticed it when you are reading your textbook or a book, and you look at suddenly something far from you*") and then produced his explanation.

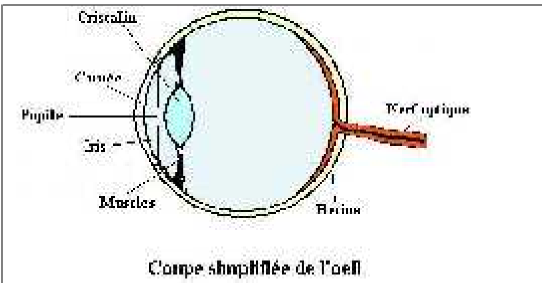	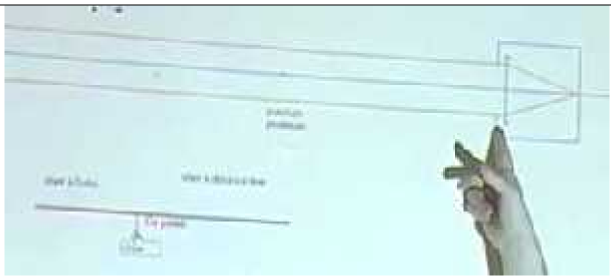
Figure 1: static representation of an eye.	Figure 2: dynamic representation of an eye, from a physics point of view; representation obtained by Cabri software; case of an object at an infinite distance from the eye.

5.2. Analysis in terms of semiotic registers

The teacher made explicit for students the difference between two semiotic registers: the graphic representation and the drawing (saying for example: *you see here is a schema, it is a schematic representation, not a drawing like what we saw last week*). Nevertheless this distinction is limited because these two kinds of representation were not present simultaneously.

Through his gestures when projecting the Cabri figure, the teacher has provided links between two semiotic registers: the schematic register and the register of natural language. In fact, the teacher pointed with his finger relevant elements on the representation; for the converging lens for example he said: "*light rays as they pass through the lens as they are all converging lens* ...." (figures 2 and 3).

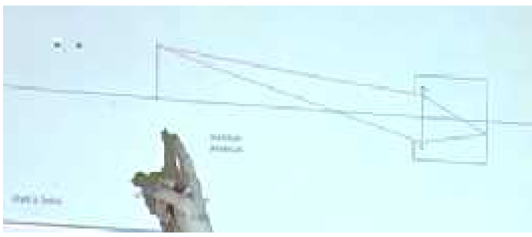

Figure 3: dynamic representation of an eye, from a physics point of view (representation obtained by Cabri software; case of an object at a finite distance from the eye).

5.3. Analysis in terms of learning opportunity

Using Cabri-géomètre, the teacher introduced a temporality to explain the convergence of a light beam after passing through a converging lens. The convergence of light may appear to be stationary (stable) when students carried out an experiment with a light and a converging lens. The use of Cabri by the teacher allows students observing the phenomenon in two phases: the light rays before crossing the lens (first phase) and the light rays after passing through the lens (second phase).
The use of a Cabri file offers to students the opportunity to visualise, for the first time, the modelling of the image obtained by a convergent lens in the case of an object at a finite distance from the lens (figure 3). The teacher gave here a new learning opportunity to students, characterised by the fact that the image is formed on the retina of the eye, whatever can be the place of the object relatively to the lens.

5.4. Analysis in terms of coherence

At many occasions during these five minutes, the teacher refered to the previous activities performed the week before by students ("*you remember*"): he recalled the experiment showing that the image through a converging lens is located in a special place behind the lens (fourth activity); but he also indicated that the situation is different for the image formation on the retina (the screen does not move), and that is his way to introduce the changes in the focal length of the crystalline, the accommodation phenomenon. Moreover he made the parallelism between the fifth activity (the schema of the eye) and the modelling of an eye in the Cabri-environment.

6. CONCLUSION

In this episode, we can observe that the meaningful articulation between the semiotic registers, the modelling levels, the activities of the sequence, allowed to this experimented teacher offering new learning opportunities to students (such as the link between their everyday life experience and the accommodation phenomenon), and strengthening the learning opportunities which had been offered in the previous sessions (like the fact that the optical image is formed in a located area behind the lens).

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SCIENCE TEACHERS' INITIAL MOTIVATION FOR DISTANCE EDUCATION

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Abstract: The science teachers play an important role in the quality of science education, and in the reforms' implementation, consequently to expand programs on teacher's continuing education is essential. As from 1996, the Brazilian Law of Guidelines and Basis of Education regulated distance education (DE), and public universities could then offer distance continuing education (DCE), broadening their role in Education. This research aims to expand understanding on factors attracting science teachers to DCE. Data were collected through interviews and questionnaires (Likert scale) with 75 participants, mainly from elementary school (80%), who took a DCE course in 2008. The results were analyzed quantitatively and qualitatively and showed a heterogeneous profile with science teachers from both sexes, wide age range, and with different experiences in distance education. The initial triggering reasons to take a DCE ranged from personal, professional, and convenience. Despite some balance among all the triggering reasons, professional ones had more influence. The DCE theme, its content relevance, and flexible schedules, were also important considerations among all others identified. These results provide public universities some elements to attract science teachers to DCE programs and to support optimal execution, contributing to the improvement of science education.

Keywords: Motivation. Distance continuing education. Science teachers.

INTRODUCTION

Teacher plays a central role in the reforms implementation (Adams & Tillotson, 1995), as well as in the quality of science education, therefore expanding programs on teachers' continuing education is crucial to improve science education (Cunha and Krasilchik, 2000).

In Brazil, several reasons make the importance of science continuing education even more acute, such as deficiencies in pre-service education (Carvalho and Gil-Perez, 2000), inadequate legislation (Garcia, Bizzo and Malacarne, 2009), and the precarious conditions of teaching (Franch, 1995).

As from 1996, the Brazilian Law of Guidelines and Basis of Education (LDBEN/96) have regulated distance education, enabling public universities (Article 80 and 87) to use innovative approaches for science continuing education.

To create attractive DCE programs for science teachers, building a deep understanding on reasons that triggers adults to enroll in such courses should be a matter of research. Rurato, Golveia and Golveia (2007b) had already proposed a transversal approach to understand the characteristics and students' motivations, because these data can provide a set of elements that can be available to construct learning strategies for students to succeed.

Although an important subject of research, the science teachers' motivation to seek DCE programs is methodologically challenging to identify and measure in a systematic approach. Several authors have explored the reasons for adults to seek DCE. Fiuza (2002) suggested a slight predominance of personal over professional ones; O'Lawrence (2007) argues that distance education' schedule flexibility enables an optimal life-work balance and was an important factor driving decisions to seek DCE; Moore and Kearsley (2007) demonstrated that improving skills for an optimal employment was the main factor. Our group has demonstrated that professional reasons play a central role in the teachers' initial motivation, specifically for science teachers (Garcia, Bizzo, Lemos, 2008).

What are the main reasons driving science teachers (or even preventing them) to seek DCE? Do personal reasons play a central role or seeking professional advancement in the career is more important? Understanding this will drive decision making to support optimal policies aiming to improve science education.

Most studies up to now do not separate reasons among sub-groups within the main study population. Do aspects such as gender, science background, age, and experience play an important role in the reasons to seek DCE?

This study aims to identify the reasons that attract science teachers to DCE. Also, this study aims to understand the impact of the teacher's profile (gender, age, education, teaching experience, and DE experience) on those reasons.

The results are relevant to universities that are interested in expanding their roles in relation to our society in general and to science education in particular. The data are also important for the construction of new distance education courses improving teacher education, and consequently the Science Teaching.

DISTANCE EDUCATION IN BRAZIL

Distance education can provide the necessary conditions for the expansion of continuing education programs. The last LDBEN/96 (Article 80 and 87) and some decrees (n. 5622, published in 20 December 2005, revoking the previous two (n. 2494 and n. 2561) regulated distance education, enabling public universities to expand their roles in relation to education and society.

The Higher Education Census of 2009 showed an advancement of distance education in Brazil. Of all enrolment held in 2009 14.1% were in this modality of teaching. There was a large increase in the number of graduates in graduate courses. In 2002 there were 133.000 graduates, and in 2009 they were already 241. 000 studying in distance education.

The Ministry of Education implemented a series of policies for the expansion of distance education. We emphasize, among others, the creation of the Department of Distance Education (SEED) and the System Open University of Brazil.

Motivation and teachers' profile

Palloff and Pratt (2003) suggest that the successful virtual student consist of working, mature people who are trying to better their opportunities, self-learners who can conduct their study schedule without having teacher to charge them, they know how to ask questions, exchange information and develop ideas.

On the other hand, Ferreira and Mendonça (2007) state, for example, that women consider the DE as a good alternative for education, because they have daily work and duties of home.

Understand science teacher profile who seeks the distance continuing education, their characteristics may help professors and tutors create new pedagogical activities. However, this profile will be better understood if it is related to other characteristics like motivation for seeking distance continuing education.

Motivation is an inner process that triggers, maintains and directs behavior. It is a psychological state, a driving force by which humans act achieving their goals (CAMPOS, 1989).

The motivation topic has promoted investigations from researchers from different disciplines. Characterized as an internal component of a person, motivation is fundamental for understanding attitudes, behavior, learning, performance, and the participation in distance continuing education.

Because motivation is not a directly observable phenomenon, it is investigated by studying people behavior in order to identify and understand the reasons underlying their inclinations and actions. Murray (1986) states that although there are multiple visions and conceptions of motivation there is a consensus that is the reason, such as internal factor, which initiates, conducts, maintains, and integrates a person's behavior.

The reasons, according to Hersey and Blanchard (1986), are synonymous of desires, instincts, impulses, needs and interests of the person. Motivation is related to the intensity of these reasons. For Lima (2000) one reason is a construct that can not be observed, and is constructed by the person to explain why he or she has the need to act in this or that way to perform an action. Thus, both the strength of each reason and the standard of them have an impact on how the person understands and interacts with the world around him.

Adults have a variety of reasons to learn and to make choices about learning. In the United States, Moore and Kearsley (2007, p. 174-175), state that students have as initial reasons for enrolling in distance education courses the compliance with university credits, the search for new knowledge, personal investment, the attempt to improve the income and employability.

Fiuza (2002), in a study of motivational aspects related to distance education in a master's degree distance course, listed a set of motivating factors (reasons) that lead workers to seek the distance education. The author has grouped the frequency of student responses showing a slight predominance on the personal aspects over professional ones. In another study, over a distance course of specialization, Gomez (2000) showed that participants were motivated to pursue the distance course by professional, personal and practical reasons.

O'Lawrence (2007) in his article "An Overview of the Influence of Distance Learning on Adult Learners" reveals, on one hand, that adults participate in distance education programs to enhance their skills, by the pressure of having to earn a diploma and because the incentives they receive from their employers. On the other, the author identified other issues such as lack of time, transport issues, optimal life-work balance, and flexibility of the course.

In a study in 2008, studying science teachers in a distance continuing education our group found that professional reasons play a central role in the teachers' initial motivation (Garcia; Bizzo; Lemos, 2008). Although in this study we only grouped the reasons (the frequency of student responses) that motivate science teachers to seek distance education.

METHODS

This study aims to identify the reasons that attract science teachers to DCE. Also, this study aims to understand the impact of the teacher's profile (gender, age, education, teaching experience, and DE experience) on those reasons.

With this goal in mind, our group decided to select a DCE science course applied by a public university for free. After identifying the study population, a sample of the teachers was selected to be interviewed (N=12) and results from those interviews were used to prepare a questionnaire. After the initial validation of the questionnaire with a pilot study (performed with 11 other teachers from the same study population), all teachers (N=138) received the final version of the questionnaire. Data collected from the returned questionnaires was compared and contrasted to achieve the study goals previously described.

The questionnaire consisted of open-ended questions and one Likert scale. We collected data on the participant profile: gender; age; academic background, graduate degree (yes/no), teaching experience (in years), and distance education exposure (yes/no). As to initial motivation for choosing this type of DCE we used a Likert scale with 27 items.

The raw data from the returned questionnaires (75 out of 138 participants) was analyzed forming three main groups of latent variables called domains (personal reasons, professional reasons, and convenience reasons). The consistency of three latent variables was checked using Alpha of Cromback, showing levels higher than 60% (according to Pestana and Grangeiro, (2005) it is acceptable to social science one alpha > 0,6).

Data were analyzed using the Statistical Package for Social Sciences (SPSS 16.0 for Windows) and "R" (http://www.r-project.org). To compare the domains related to gender, graduate degree, previous exposure to DE, nonparametric tests (Mann-Whitney test) were used. To compare the teaching experience and the three main domains, the Kruskal-Wallis was used. The correlation between age and each of the domains' variables was analyzed using "p" Spearman. To determine which domain had the greatest impact on the science teachers' initial motivation, Friedman' test was used. For all comparisons, we adopted a significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

The selected course was performed annually by Sao Paulo University. Data was collected from the 2008 class. The course theme was "Nutritional Education: the food label in the classroom of elementary science education". The objective was to update science teachers in nutrition. The course had 60 hours performed over two months, with 58 hours of distance education and two hours final test (in person). From the 138 questionnaires submitted, 75 answered questionnaires were returned.

Results from the answered questionnaires showed teachers from different regions: South, Southeast, Midwest and Northeast. They were mostly women (80%) with an average age of approximately 33 years. Fifty-eight percent majored in Biology with a graduate degree (52%). Nearly 54% (53.3%) worked in a state public school, 78,3% in elementary school, 55.9% had more than five years of teaching experience, and 52% did not have any experience in DE.

The science teachers' initial motivation (reasons) to participate on the course varied widely. The higher scoring items are described below (table 1).

Table 1 – Science teachers' initial motivation (reasons) – 2008

	Statement	Mean	SD
MI03	**Interest on the course topic for my classes**	**3,84**	**,436**
MI10	**Improve my professional knowledge on the topic**	**3,71**	**,653**
MI11	**Use professionally the acquired knowledge on my students**	**3,50**	**1,113**
MI21	**Flexible schedules**	**3,35**	**1,020**
MI15	**The fact that the course could improve the quality of my classes**	**3,31**	**1,185**
MI25	**The possibility of reconcile work and continuing education**	**3,28**	**1,008**

MI24	**Opportunity at the time the course was open**	**3,27**	**1,031**
MI23	**Technology, tools available (to attend the course)**	**3,24**	**,867**
MI06	**Because the course was free**	**3,22**	**1,264**
MI26	**The possibility of reconciling family life and work**	**3,11**	**1,169**
MI08	**Interest in information to improve my personal nutrition**	**3,05**	**1,038**
MI01	**Interest in taking a distance course in Nutrition Education**	**3,03**	**1,273**

Among the most mentioned items, three were in the personal domain (MI01, MI06 and MI08), four to the professional (MI03, MI10, MI11, MI15) and five to the convenience (MI21, MI23, MI24, MI25, MI26). These reasons were the most important and influenced science teacher's decision to seek a DCE.

In the analysis of the interface between domains and variables (sex, age, graduate degree, teaching experience, and previous exposure to distance education), it was noted that all three domains were important influencers of the decision making to take a DCE. However, when teachers had higher levels of education (graduate degree, p=0.014) or with longer teaching experience (p=0.013), the professional domain had a more impact. Other analyzes yielded no statistically significant differences.

The test applied to analyze the correlation between each of the three domains showed that the professional domain (Median=3,00) was the most relevant to the science teacher's decision making.

SOME IMPLICATIONS

Data described previously listed the reasons to attract adults to distance education (Fiuza, 2002; O'Lawrence, 2007; Moore and Kearsley, 2007). The results presented here further expand the understanding on the science teachers' initial motivation to take a DCE course. Furthermore, explore how the teacher profile (gender; age; academic background, graduate degree, teaching experience, and distance education exposure) impact on the motivation to take a DCE course.

Rurato, Golveia and Golveia (2007b), in a study on the characteristics of students in distance education and the motivating factors, proposed a transversal approach to know the characteristics and motivations of students. According to these authors, these data can provide a set of possible elements helping professors to construct learning strategies for students to be successful. However, our results suggest more than a simple cross-cutting approach to know the characteristics and motivations of science teachers. They point to the need to explore the science teachers' profile attracted to the DCE and connect it to the initial motivation.

The implications of those conclusions bring the need to ensure a deep understanding of several aspects of the DCE to design an optimal course. In those three domains is required a combination of the theme, current and relevant, the relevance of knowledge, current, contextualized with links to teacher personal and teacher professional life, and schedule flexibility enabling an optimal life-work balance

Also it is relevant to shape courses differently to specific subgroups of teachers according their initial motivations. Those science teachers with higher levels of education or with longer teaching experience, who were attracted by professional reasons, and the others, who were attracted by personal or convenience reasons, need to have their interests assisted in different pedagogic perspectives.

Finally, we stress that these results are important to universities. Public universities can expand their roles in relation to our society in general and to science education in particular.

They have enough information to attract science teachers to DCE programs and for the construction of new DCE courses improving teacher education, and consequently the science education.

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PRACTICES IN THE TEACHING OF SCIENCES IN SCHOOL INCLUSION OF A BLIND PUPIL WITH DELLEMAN SYNDROME

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Abstract: This research investigates the use of Assistive Technologies (AT) in the process of inclusion of a visually impaired pupil based on different actions involving the teaching of Sciences, the school community and the family. A qualitative research approach was used, and a case study framework was adopted. The field of study was a state school in the city of Boa Vista, Roraima, Brazil, which accepts people with special needs in regular groups of the elementary school years. The object was the teaching of Sciences. The subject was a blind student with Delleman Syndrome who has undergone 21 surgeries. The subject uses AT as resource to assist in school attendance, in the personal development process and in the construction of knowledge and learning since early education. Interviews on the object of study were also conducted with teachers of Sciences in ordinary groups with special pupils and teachers working in teaching rooms equipped with visual resources. This approach afforded to understand the reality being investigated.

Keywords: School Inclusion; Assistive Technologies; Pedagogical Practices for the Teaching of Sciences.

INTRODUCTION

In Brazil, the National Policy for Special Education in the Perspective of Inclusive Education established the right to education to all children with special educational needs. In this sense, one of the focal points of this policy is regular teaching practices in conjunction with specialized educational service, which has to be offered before or after the respective daily school shift. Programs to enrich curricula, language teaching and specific communication and signaling codes also have to be included, apart from Assistive Technologies (AT).

1. THE TEACHING OF SCIENCES IN THE SPECIAL EDUCATION CONTEXT

The need to promote and develop the teaching of Sciences lies in the fact that these variables afford the student to better follow the evolution of science as well as the transformations that take place in nature and in human history. In this context, apart from being informative, the teaching of Sciences may also endorse scientific reasoning.

With this objective in mind, the Ministry of Education (MEC) implemented the National Curriculum Parameters (PCN) and, in the context of Special Education, adopted a set of guidelines titled "Curriculum Adaptations of National Curriculum Parameters in the Teaching of Pupils with Special Needs" (BRASIL, 1998).

The teaching of Sciences to visually impaired pupils demands from the teacher more than the development and application of activities focused on the content to be taught. Ironically, the persistence of a methodological and conceptual link observed between these teaching contents and visual didactic and pedagogic models adopted in scientific theories makes it more difficult for the teacher to bridge the didactic transposition as expected (CAMARGO *et al*., 2006).

Another aspect that deserves to be stressed is the fact that Assistive Technologies may be used as interfaces in the learning process, which leads to more intense interaction and independence of the blind pupil in the classroom environment, promoting learning skills.

2. The pedagogical practice in Sciences: the data obtained

This study relied on the cooperation of eight teachers of an elementary school in the State of Roraima, Brazil. Based on the roles each teacher performed, they were identified as follows: two Sciences teachers (P1 and P2), one educational advisor (P3), the school's principal (P4), one classroom teacher (P5) and three visual resources teachers (P6, P7 and P8). The subject assessed in the present study was a 17-year-old 6th grade junior high pupil called R., who has oculocerebrocutaneous syndrome (OCCS), also called Delleman Syndrome. This disease is a multiple syndrome of congenital anomalies characterized by orbital cysts, brain malformation, congenital cleft upper lip and palate, neurosensory deafness and focal dermal hypoplasia. However, the subject who participated in this study did not present brain malformation (BRANDÃO, 2010).

The periods the teachers who took part in this research were working with blind pupils varied between 1 and 10 years, mean 4.25 years. Concerning specialized teacher training, five teachers declared having no specialized education in teaching blind pupils, three informed that they had taken a specialization course for teaching special pupils, and these same teachers said that had taken a further education course and/or participated in occasional training programs to meet the needs of blind pupils.

In terms of the knowledge of the Braille system, the two Sciences teachers said that they did not know the system and that only the teachers assigned to visual resources activities had specific training for that purpose. The same was observed concerning the teachers assigned to pedagogical tasks in the school.

When analyzing the pedagogical practices carried out by teachers and how ATs are used by R. in Sciences classes in terms of accessibility, inclusion, formation, as well as the knowledge and the perceptions the teachers have about these technologies and their notions concerning teaching and learning using ATs in the case of a disabled subject, we observed that:

- The views about teaching, learning and visual impairment vary considerably among the members of the study group, from a transmission-reception approach to a view based on the interaction between teacher and pupil.

- Considering the teaching process that resorts to ATs, only the visual resources teachers understand that the teaching process is not restricted to the classroom and the blackboard. For these teachers, "there is no single way to teach; everything depends on the pupil's needs" and "the creativity of individual teachers is very important".

- Considering the learning process, the teachers did not identify the difference between the use of ATs and the blackboard. The didactic strategies and/or tools they utilize in the classroom so as to facilitate the learning by a blind pupil in Sciences classes are the "blackboard", "speaking louder, nearer to the pupil so as to afford him to listen in better", "dictations of the activities for the pupil to copy". However, both stress the fact that the visual resources classroom is the site that has the technological and didactic resources that facilitate the learning by blind pupils.

- Three teachers answered directly that the technological and didactic resources that facilitate learning are located in the visual resources classroom. One of these teachers stresses the fact that these "are essential resources in the learning process", mentioning "the importance of the slate and of the stylus, since the blind pupil is unable to write without these instruments". Also, it was said that "the use of the Braille System is the first step for the inclusion of a blind pupil". Three teachers did not answer the questions about learning.

- The words of the Sciences teachers afforded to observe that they use the visual resources classroom as the only technological tool, since "it is the place where capacitated professionals are available to direct pupils in their extra-class or complementary classroom activities".

The techniques and strategies used by teachers of Sciences evaluated here are still based on expository classes. When planning the activities in a classroom with visually impaired pupils, it is the teacher's duty to offer the pupil the conditions and opportunities to explore his/her own intellectual skills, promoting a multi-sensory learning process (SILVA, 2006).

Concerning the pedagogical practices in the classroom that aim at the pupil/teacher and teacher/pupil interaction, teachers P1 and P2 underline the importance of classes based on traditional methodologies, as in the "blackboard", as well as of the sporadic group work and of Sciences lab classes. In R.'s own words, "In the Sciences lab she allowed me to grab things so as to better perceive them".

When commenting on the didactic strategies and/or resources used in the classroom to facilitate the learning of Sciences, P7 says, "The material is adapted as requested by the teacher and he would very properly say that that material was not good for him and that it needed adaptation".

The interviews with the teachers and the *in loco* observation carried out during the two years (2008 and 2009) R. was assessed prove that the subject did not feel difficulties to follow scientific reasoning and that he was very skilful in writing the classroom exercises in the Perkins device.

3. Conclusion

The analysis of the data collected in the school investigated indicate the rather limited understanding teachers have of the inclusion of special educational needs, ATs, and didactic resources for the blind and visually impaired. According to these teachers, considering R., learning and teaching using ATs (inclusion) takes place in the visual resource classroom.

The data collected and analyzed afford to observe the considerable limitations around the understanding of school inclusion, inclusion of pupils with special education needs, AT and didactic resources for the blind and those with visual impairment, from teachers P1, P2, P3 and P4, in the school where this research was conducted, in the state of Roraima, Brazil. In the opinion of these teachers, more specifically concerning the pupil R., teaching and learning using ATs (inclusion) take place in the visual resources classroom. However, P6 and P7, who are assigned to the classroom mentioned, understand that teaching and learning do not depend on the physical space as such, and that these activities are indeed influenced by the needs of a given pupil.

In this sense, the teaching of Sciences using these technologies, more specifically for R., and ATs, may add to supporting issues of didactic/pedagogical character more directly related to everyday school activities. Additionally, these technologies may enable the conditions to understand how the pupil with visual impairment interacts with reality, effectively developing his own learning processes.

Finally, the use of ATs in the teaching of Sciences not only facilitates accessibility and social inclusion of visually impaired subjects, but also promotes the teaching and learning of the subject, affording the pupil the tools to search for information he or she needs and (re)constructing his or her own knowledge.

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PRESCHOOL SCIENCE EDUCATION WITH THE USE OF ICT: A CASE STUDY

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Abstract: In recent years we have become increasingly aware of the need for people to understand the nature of science in order to make decisions posed by new developments in both science and technology. This case study is part of a wider research project concerning the use of Information and Communication Technologies (ICT) for teaching main natural science's concepts and mathematics in early year's classroom. The study was conducted during 2010-2011 school year and 270 pupils were participated. The integration of ICT into preschool education has become a high priority for everybody involved in the learning process. The Early Numeracy Test was given to pupils and semi-structured interviews with young children were conducted in 18 preschool classes in Crete. Pupils in the control group received only the traditional science instruction about natural sciences (solubility, recycling) and mathematical concepts (comparison, classification and general knowledge of numbers). Pupils in the experimental group received only the science instruction with the use of ICT for the same topics. Both the experimental and the control groups consisted of classes from the same participating schools. The incorporation of ICT in early year's classes in Greece should be considered as a means of an obligatory modernization of learning and teaching methods. The results of our research showed that teaching and learning through ICT as an innovative teaching method can be successful for understanding the concept of numbers and natural sciences phenomena at preschool level.

Keywords: Preschool Education, Mathematics, Solubility, Recycling, ICT.

INTRODUCTION

Science, apart from representations of the world, also involves ways of intervening in the world by putting things to work in the laboratory according to theories and models. Scientific literacy, the goal of science education, involves conceptual knowledge, problem-solving strategies, understanding the nature of science, and an appreciation of the interaction between science and society (Stohr-Hunt, 1996).

Science education at the preschool level with the use of ICT (Information and Communication Technologies) that emphasizes active learning, may be expected to promote higher student motivation than what occurs in traditional classroom settings with teacher oriented learning. Numbers and natural phenomena invoke the interest of children from a very young age (Geary, 1994; Bryant 1997; Chen, 2009). Our research reveals ICT uses in Greek preschool education and explores this use of ICT for science education.

THEORETICAL FRAMEWORK

During the last 10 to 20 years European countries have had problems engaging students in science (Osborne & Dillon, 2008). Children construct their knowledge of the world on the basis of two information sources-observations of the world and explanations given by other people (Vosniadou, 2002; Kikas, 2003).

Scientific concepts may be hard to grasp even by adults; however, this does not mean that children cannot think abstractly about scientific concepts. On the contrary, literature shows that children are able to think about even complex concepts (Zimmerman, 2000). Learning theories now accept the importance of learning processes at this age and, moreover, research studies have provided strong evidence that appropriate teaching interventions can help pre-school children accept basic scientific ideas concerning common phenomena of the natural world (Ravanis, 1994).

Pupils’ responses to events involving changes of state and dissolving have been studied in a variety of contexts over the past two decades. For Slone and Bokhurst (1992) the child is be able to consider both variables, the sugar and water, simultaneously (dependent on preservation), must understand direct and inverse relations (dependent on liquefaction or atomism), and must have the ability to assign numbers to the amounts of sugar and water and to compare the ratios. According to Prieto, Blanco and Rodriquez (1989), ideas held by 11 to 14-year-old Spanish students about solutions and the process of dissolution attach a good deal of importance to the mechanical actions and manipulations involved in dissolving the substances (e.g., stirring, shaking, heating, etc.). Lee et al. (1993) have reported about 50% of a sample of 11 year olds demonstrating an understanding of particle explanations for states, change of state, expansion and dissolving. For Papageorgiou and Johnson (2005) particle ideas helped with the development of 10/11 years old pupils’ understanding of phenomena of changes of state and mixing.

In addition environmental education is recognized as an educational process that significantly promotes all aspects of an overall and balanced personal development of young children, in the psychological, emotional, cognitive, social and psychomotor sectors (Flogaitis, Daskolia & Liarakou, 2005). However, although the significance of environmental education in early childhood education has been recognized early on internationally (Tilbury, 1994) and efforts have been made for its inclusion in kindergarten schools, research in the field remains largely limited. Despite the fact that environmental education’s general conceptual and methodological framework is widely accepted by the Greek educational community, the matter of its interpretation by national educational policy-makers and the approaches they promote for the application of environmental education at each educational level remains open (Flogaitis, et al., 2005).

The adequate preparation of teachers at all school levels in environmental education is considered, even today, to be lacking. The main emphasis has been primarily placed on the in-service training of teachers with the thought that most practitioners have not received any relevant pre-service training in environmental education (Flogaitis, et al, 2005).

A vast number of studies relate the appropriate use of computers with the ability of students to understand more efficiently the different mathematical notions (Dunham & Dick, 1994; Groves, 1994). Thus, it becomes obvious that kindergarten emerges as a very attractive environment of investigating the computer use in mathematics education. Indeed, various research results show a positive interrelation between the use of computer and the development of mathematical thinking in kindergarten (Clements, 2002; Clements & Sarama, 2004).

We consider it necessary to think of planning various activities related to science and technology, so that preschoolers would broaden their field of experiences and construct certain primary representations, which would later on form the background to build up scientific concepts (Solomonidou & Kakana, 2000). Science education at preschool level with the use of ICT that emphasize active learning, may be expected to promote higher students motivation than occurs in traditional classroom settings with teacher-directed learning.

ICT use has been applied experimentally at the preschool level on a wide scope of skills and knowledge acquisition. Results demonstrated a significant contribution of ICT use in the classroom as a learning tool (Clements & Nastasi, 1992; Clements & Sarama 2003; Vernadakis et al., 2005). It is well known that children learn faster in an interactively functioning learning environment. This is probably the most important advantage of ICT use in the teaching process against traditional teaching. Moreover, the use of computers as a teaching tool allows children to learn at their own individual pace (Zaranis & Oikonomidis, 2009). Upon achieving one level of knowledge they can proceed to the next, which is not the case in traditional teaching.

Generally speaking, in order to maximize the benefits of ICT use in education, all the educators should keep in their minds this question: 'Can we use technology to teach the same old stuff in the same way or can we capitalize on the benefits of technology by using integrated computer activities to increase achievement? (Clements & Sarama, 2002).

METHODOLOGY

Our research study uses Early Numeracy Test (ENT) (Schopman et al., 1996; Aunio et al., 2004) and audio-recorded semi-structured interviews about solubility and recycling to explore the use of ICT in preschool classroom for teaching basic mathematical and natural sciences concepts. The ENT is a task orientated test which attends to measure the level of early mathematical competence. The test has been developed for kindergarten and consisted of forty items. The ENT consisted of eight parts and the tasks were spread over these parts in group of five. The ENT was examined individually. The components of the ENT where our study focused were: concepts of comparison, classification and general knowledge of numbers.

The semi-structured interviews focused especially on: solubility and recycling. The following questions were examples of what we asked the students: Does lentils, beans, chickpeas, rice, sugar, salt, pepper, and, coffee dissolved in water? What do you think when you hear the word recycle? What is recycling? Recycled camera? Recycled food cans, plastic bottles, stones? What is it made with the scissors, books, and bottles? Which buckets dump the plastic bottles, newspaper, and metal teapot? Recycled food? Draw a trashcan and a material that we throw into it when you do not need it anymore.

The study was conducted during 2010-2011 school year and 270 pupils were participated. The Early Numeracy Test and audio-recorded semi-structured interviews were conducted one-to-one in private and were given to children, aged from 4 to 6 years randomly selected, in 18 preschool classes in Crete (Greece). It took about half an hour for each interview or test and they were given to the children as a pre-test and post-test before and after the teaching intervention. There were two groups in the study, one control and one experimental. In the control group there was not a computer available for pupils' use, while in the experimental there was one. The research study was conducted from November 2010 to April 2011.

Pupils in the experimental group received only the science instruction with the use of ICT for the same natural sciences phenomena and mathematical concepts. Both the experimental and the control groups consisted of classes from the same participating schools.

The teaching process for both groups consisted of four weekly syllabus. The control group coordinated with traditional teaching. That included a story about the three little pigs that had three bags with sugar, beans and salt and passed through a great river. Another story was of recyclable materials, bottles, cans and paper that were neglected at the beach and they were very sad because they had been used and felt useless, until one day the newspaper brought the good news of recycling. Group and individual activities were given to children every day in order to understand what materials were recycled in the yellow bin, which the green and what in the blue bin. In addition they did experiments in which dissolved in water, various materials as sugar, salt, beans, chickpeas, lentils, coffee, etc. Moreover, there were quizzes given periodically and procedures were given at the conclusion of each number form one to ten.

The experimental group covered the same material at roughly the same time, but spent one class hour per week with the computer. The software was designed using the Flash CS3 professional environment and consisted of six distinctive counting activities for numbers from one to ten. Each one of them implicated pupils into different aspects of counting situations. More accurately, pupils were asked to reach solutions to problems, in which counting played an integral role. The computer activities were selected according to the kindergartens' curriculum and complements what children had been previously taught in class. The general environment of the software could be described as open ended, which allows pupils freedom of use and navigation, although there were some drill and practice features as well. Concerning the natural sciences phenomena the teaching intervention of experimental group used software which included stories and activities about solubility and recycling.

The role of the main teachers and student teachers were to be facilitators to help children solved any problems, but only when children really needed help. The data analysis from the tests was carried out using SPSS (ver.19.0).

RESULTS

The ENT and interviews were taken by 270 pupils. One hundred and thirty one of the pupils were male and one hundred and thirty nine were female. Data analysis was done by the SPSS statistical analysis program. Independent samples and paired samples t-test were carried out. The independent variable had two categories the experimental group (132 children) and the control group (138 children). The dependent variable was the total pupil's score from the semi-structured interviews about natural sciences phenomena (solubility and recycling) and mathematical concepts (comparison, classification and general knowledge of numbers).

The t-test for equality of means was not significant ($t = -0.684$, $p = 0.495$), indicating no significant differences initially, in numeracy and natural achievements between the experimental and control groups. Though the experimental group had a mean score ($m=25.822$) slightly higher than the control group ($m=25.517$), the mean difference was less than -0.300. The results of this pre-test are summarized below (Table 1):

Table 1: Independent Samples Test of pre-test

	t	df	mean difference	Sig. (2-tailed)
PRE-TEST	-0.684	206	-0.300	0.495

In order to determine if the performance of the experimental group was significant, a paired t-test was performed using the grades of this group for a comparison between pre-test and post-test of the scores. The mean grade for the pre-test of the study was 25.82 (SD= 4.39) compared to 35.35 (SD= 2.41) of the post-test. At $\alpha = .05$ and df = 131, the critical value of the t ratio was less than 0.001 (Table 2). Therefore, the post-test score was significantly different from the pre-test score in the experimental group.

Table 2: Paired Samples Test of pre and post tests in the experimental groups

	t	df	Mean	Sig. (2-tailed)
Pair 1 pre-test- post-test	-29.036	131	-9.530	0.000

Similarly, to determine if the performance of control group was significant, a paired t-test was performed using the grades of this group for a comparison between pre-test and post-test of the scores. The mean grade for the pre-test in the study was 25.52 (SD=2.51) compared to 34.65 (SD=3.23) for the post-test. At $\alpha = .05$ and df=137, the critical value of the t ratio was less than 0.001 (Table 3). Therefore, the post-test score was significantly different from the pre-test score in the control group.

Table 3: Paired Samples Test of pre and post tests in the control groups

	t	df	Mean	Sig. (2-tailed)
Pair 1 pre-test- post-test ENT	-31.512	137	-9.130	0.000

Finally, an independent sample t-test was conducted. The t-test for equality of means was significant ($t = -2.007$, $p = 0.046$), indicating significant differences, in the scores between the experimental and control groups. The results of this post-test are summarized below (Table 4):

Table 4: Independent Samples Test of post-test

	t	df	mean difference	Sig. (2-tailed)
POST-TEST	-2.007	268	-0.700	0.046

Results of this study expand the research on the effects of appropriate programs embedded in a computerized environment for mathematics and natural science (Ravanis, 1994; Dunham & Dick, 1994; Groves, 1994; Solomonidou & Kakana, 2000; Clements, 2002; Clements & Sarama, 2004; Flogaitis et al., 2005).

CONCLUSIONS - DISCUSSION

Results of this study tend to confirm that ICT can be an effective method for teaching selected beginning scientific concepts and skills. Initially, there was no significant difference between the experimental and control group achievements. However, throughout the study, the experimental group had higher achievement than the control group. Despite that, both the experimental and control group had great achievements between the starting and the final level.

Using ICT appropriately with young children for science teaching is vital in early childhood settings. Pupils like use ICT mostly because it is something new compared to a traditional science lesson. Providing computers in each preschool classroom does not mean that the teacher will incorporate effectively ICT for science teaching. It is essential that early years teachers should be trained in the ability to apply ICT and to interact with the children during the learning process. Attending training programmes and keeping an open mind are the keys to a teacher's success.

This study is preliminary in its nature and is in progress. Other studies need to be designed, in order to replicate this treatment with a larger number of subjects and to attempt answering other questions that did not arise in this research.

The use of ICT in early childhood education is not a panacea and researchers ought to study more deeply the complex pedagogical issues involved in the uses of ICT. We argue that a change is necessary so as an innovative teaching method can be successful, not only concerning materials, but also concerning approaches and beliefs.

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KNOWLEDGE ORGANIZATION IN UNIVERSITY PHYSICS TEXTBOOKS

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Abstract: Textbooks are often the major source of knowledge in science education that provides teachers and students a conception of how scientific knowledge is organized. Therefore, it is of interest to recognize how knowledge is organized in the textbooks. In this study the knowledge organization in three introductory university physics textbooks are analyzed from the viewpoint of how concepts are structurally related. The examined subject is magnetostatics with specific topics of Biot-Savart law and Ampère's law. The method of analysis is based on the interpretative analysis and categorization, which recognizes the basic elements and basic links, which connect these elements. These basic elements and links form the skeletal structure of knowledge organization. Finally, the knowledge organization of textbooks are represented by using concept maps and classified qualitatively on the basis of their topological outlook, revealing the essential differences in their structures.

INTRODUCTION

The crucial role of textbooks on student's learning has been highlighted in many studies. For example, in National Educational Goals Panel (1998) of United States, there are some recommendations regarding the implementation of standards "Textbooks are where students meet the standards." It suggests that students and teachers should have instructional materials such as textbooks, which could help them to meet academic standards. Roseman et al (2010) analyzed the contents of four biology textbooks in order to examine their coherency. They specified the key ideas as well as other ideas within the textbooks and the alignments and connections among them. They reported that the judgments of their review team about the connections among key ideas were less consistent than the judgements about connections among key ideas and other ideas. Moreover, they noted that guidelines that were provided for making judgments about alignments were more explicit than guidelines about connections. In this research, it has been attempted to construct an explicit guideline for basic elements as well as guideline for connections (links) between basic elements.

Knowledge organization is an important component of understanding learning and teaching (Novak, 1982). diSessa (1993) argues that gaining an organized and integrated knowledge is a basis for cognitive processing (e.g. problem solving or complex reasoning). Teachers rely on textbooks in order to know how they should teach. Teachers would benefit considerably from textbooks if they are able to recognize and use such effective structures of knowledge organization in their own teaching (Ball & Cohen, 1996; Davis & Krajcik, 2005).Therefore, the in-depth understanding of the knowledge organization assists teachers to arrange their teaching materials. Similarly, understanding how knowledge organization possibly affects learning process is equally important. Knowledge organization is without doubt an important basic problem in all learning and teaching, but where do teachers and students actually get examples of those organized knowledge. For example, comparing knowledge organization of experts and novices has revealed that experts have an integrated and efficient knowledge organization with meaningfully related elements (e.g. principles and concepts) while students often have difficulties to organize their knowledge (e.g. students do not have sufficient interconnections between the pieces of their knowledge). Quite naturally, the study materials such as textbooks guide the development of knowledge organization of both teachers and students. These notions motivate to find out how knowledge organization differs in different textbooks.

THE METHOD OF ANALYSIS

The purpose of this study is to find a way to present how knowledge in a textbook is connected and what kinds of structures knowledge organization these connections form. In order to make this explicit, the following research questions were established:

1. What are the characteristics of links (forming the knowledge organization) in different textbooks?

2. What kinds of knowledge organization exist in textbooks and how these organizations are different?

The first task is to develop a framework for analysing the units forming the knowledge organization. This includes recognising the basic elements like concepts and laws in the textbooks. Then the ways of connecting these basic elements (called here the links between the basic elements) are categorized. After developing the framework, the knowledge organization in the textbooks could be presented by using concept maps based on the categorized basic elements and links. In the recognition of the basic elements, the classification of elements suggested by Koponen and Pehkonen (2010) is utilized that posited that basic elements include concepts, entities, particular laws or law-like relations and principles.

After the basic elements were recognized, the connections between the basic elements in the textbooks were examined. In order to examine these connections (links), preliminary ideas of possible categorization were formed based on the role of experiments and modelling in the construction of knowledge (Koponen & Mäntylä, 2006). From the basis of earlier studies (Koponen & Mäntylä, 2006; and references therein), a category for experiments in connecting the basic elements was one reasonable possibility. However, the experiments were not detected in the studied textbooks in the cases of Biot-Savart law and Ampère’s law. Harrison and Treagust (1998, 2000) investigated the textbooks stressing the use of models. They developed a typology of school science models to classify the textbooks’ models. Their typology consists of mathematical and theoretical models, analogical models, models depicting multiple concepts such as maps, diagrams. Van Heuvelen (1991) classified physics knowledge into four main categories: words, pictorial representation, physical representation and math representation. In his classification, models somehow help students to construct representation of physical process, reason about the process, construct mathematical representations, and finally solve physics problems qualitatively.

Before forming the knowledge organization of textbooks, the classification of elements and links were judged in order to increase the validity of the analysis. For this purpose altogether six questionnaires (two topics and three textbooks) concerning the classification of basic elements and links in textbooks were designed. Four reviewers answered the questionnaires (i.e. judged the classifications made). These four reviewers are university lecturers with Ph.D. in physics, and they have taught first year physics courses. Hence, they are experts of the chosen topics of Biot-Savart law and Ampère’s law, and they are familiar with the introductory university physics textbooks. Finally, the concept maps that depict the knowledge organization of textbooks were drawn. When drawing the overall concept map, these structure elements are put together: basic elements as nodes and the categorized connections as links between nodes. Here the application of concept maps differs from the traditional way: in a link of the map there is, instead a verb, a procedure that connects the basic elements to each other (compare with Koponen & Pehkonen, 2010). Then the features of the knowledge organizations of textbooks made visible through the concept maps were qualitatively interpreted, analyzed, and compared. Calculating mean value and standard deviation of the items of questionnaires validated the interpretation and analysis of the basic elements and links forming the knowledge organization.

RESULTS

Recognized basic elements

Considering the topics of Biot-Savart and Ampere's law, BE are identified and presented in Table 1.

Table 1. Basic elements and their types identified in three studied textbooks.

	FLS	Type		HRW	Type		Knight	Type
1.	**Magnetic field**	**Concept**	***1.***	***Magnetic field***	***Concept***	***1.***	***Magnetic field***	***Concept***
2.	**Electric current**	**Entity**	***2.***	***Current- element***	***Entity***	***2.***	***Current- element***	***Entity***
3.	**Electric field**	**Concept**	***3.***	***Electric field***	***Concept***	***3.***	***Electric field***	***Concept***
4.	**Gauss's law**	**Law**	***4.***	***Gauss's law***	***Law***	***4.***	***Gauss's law***	***Law***
5.	***Biot-Savart law***	**Law**	***5.***	***Biot-Savart law***	***law***	***5.***	***Biot-Savart law***	***law***
6.	**Magnetic field of straight wire**	**Law-like relation**	***6.***	***Magnetic field due to a current in long straight wire***	***Law-like relation***	***6.***	***Magnetic field of a long straight wire***	***Law-like relation***
7.	**Magnetic field of a solenoid**	**Law-like relation**	***7.***	***Magnetic field of a solenoid***	***Law-like relation***	***7.***	***Magnetic field of a solenoid***	***Law-like relation***
8.	**Ampere's law**	**law**	***8.***	***Ampere's law***	***law***	***8.***	***Ampere's law***	***law***
9.	Vector potential	Law-like relation	*9.*	*Magnetic field of a coil*	*Law-like relation*	*9.*	*Magnetic field of current loop*	*Law-like relation*
10.	Stokes theorem	Law-like relation	*10.*	*Superposition*	*Principle*	*10.*	*Superposition*	*Principle*
11.	Maxwell equation	Law-like relation	*11.*	*Magnetic field inside a long straight wire*	*Law-like relation*	*11.*	*Magnetic field inside a current carrying wire*	*Law-like relation*
			12.	Amperian loop	Entity	12.	Coulomb's law	Law
			13.	Magnetic field due to current in a circular arc of wire	Law-like relation	13.	Magnetic field of current	Law-like relation
			14.	Magnetic field of brain activity	Law-like relation	14.	Magnetic field lines	Entity
			15.	Magnetic field of toroid	Law-like relation	15.	Charge	Entity
			16.	Magnetic field outside a long straight wire	Law-like relation			

*** Common basic elements in three textbooks are indicated by Bold. Common basic elements in HRW and Knight are indicated by Italic.**

Basic elements in all of the textbooks are identical. They have eight basic elements in common (from 1 to 8 in Table 1). The textbook of FLS has less basic elements than the other two textbooks; moreover this textbook includes some advance basic elements (e.g. Vector potential, Stokes theorem, Maxwell equation). The textbooks of HRW and Knight have eleven elements in common (from 1 to 11 in Table 1).

Categorization of links

The method of analysis and categorization of links needs consistently to specify the nature of links and to show how they connect the basic elements. In examining how the basic elements were connected, the links were categorized as follows:

1. Descriptive model (DM): A mathematical model that connects basic elements through mathematical relations or equations. In general, descriptive model links basic elements with mathematical format to new laws with mathematical expressions.
2. Explanatory model (EM): A mathematical model, which links basic elements through mathematical expressions. Usually the explanatory model connects the applications or implementations of laws (with mathematical format) to the closely related laws. In contrast

to descriptive model, which describes new laws, explanatory models explain the applications and implications of the defined laws.

3. Visual model (VM): This model applies for visual perceptions. Visual model connects different basic elements through the diagrams, photos, and figures.

4. Statement of fact (SF*):* Concerns declarative knowledge. This knowledge gives information about the facts such as observations, discoveries, and phenomena.

5. Reasoning (R): A mode of presentation, which can be considered also as a model that gives reasons or arguments to justify the connections between basic elements. Reasoning might be inductive reasoning (reasons are based on the previous experiences or observations or laws) or deductive reasoning (reasons follow a set of premises).

6. Reference to previous knowledge (RPK): A model, which refers to previous knowledge. This is often done in a form of analogy.

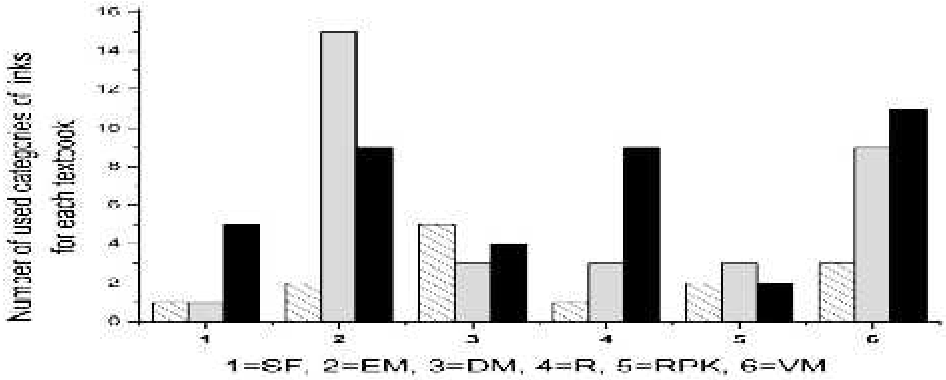

Fig 1. The number of categories of links. Used categories of links in FLS are shown by dashed bars, in HRW by gray bars and in Knight by black bars.

When comparing the total number of links, it can be seen that in FLS, there is only 14 links altogether and in Knight, there is 50 links. The HRW is between these two with the number of 34 links. Although, there is not a big difference in the number of basic elements between studied textbooks, but there is a big difference in the number of links between the textbooks (Table 1). In Fig 1, the number of links in respect to the types of links (1-6) in case of each textbook is presented in bars. It means that the tallest bar for each category (link) is the most applied link and the shortest bar is the least used link. It can be seen from the Fig 1 that in Knight (black bars) the different types of links are used in versatile ways. In FLS, the number of links (dashed bars) is low in comparison to other textbooks. In case of HRW, there is a clear emphasis on explanatory and visual models.

Representing knowledge organization of textbooks by concept maps

Since review team validated developed framework and created links, it is possible to make concept maps representing knowledge organization for each textbook. The recognized basic elements (presented in Table 1) are the concepts and connections between them are the categorized links (see last section). The concept maps are tried to construct in hierarchical fashion, where the hierarchical structure of a specific domain of knowledge depends on the context in which the knowledge is applied. The concept maps here include also cross-links, which connect different domains or segments of knowledge. The concept maps here differ in relation to the most prevalent way of constructing concept maps in one way: instead of propositions, the links are the categorized modelling procedures.

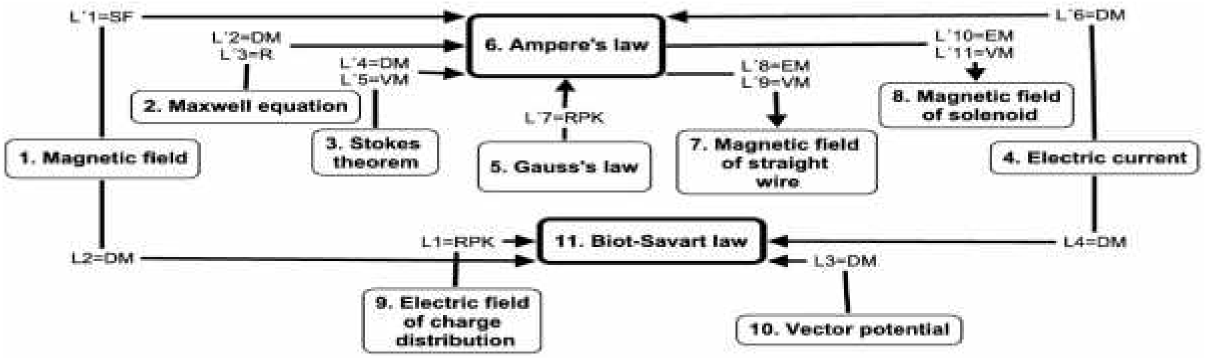

Fig 2. Concept map representing the knowledge organization of the textbook of FLS.

There are some incoming and outgoing links to Ampere's law (hierarchical structure) (e.g. Ampère's law connects to magnetic field via statement of fact, L´2=SF). There are only incoming links to Biot-Savart law (hierarchical structure), (e.g. electric field of charge distribution is utilized as an analogy (a type of RPK=L´1) to Biot-Savart law). Moreover, there are only two cross-links for the concept map of FLS. As Fig 2 shows, the knowledge organization of FLS has limited hierarchical levels, which means there are only few justifiable levels in the knowledge organization of FLS. The most dominant links in FLS are incoming links. Moreover, FLS includes few outgoing links and cross-links so its knowledge organization is not an interactive process. Ultimately, the knowledge organization of FLS can be interpreted as a simple structure that excludes interconnectedness but includes many disjointed concepts.

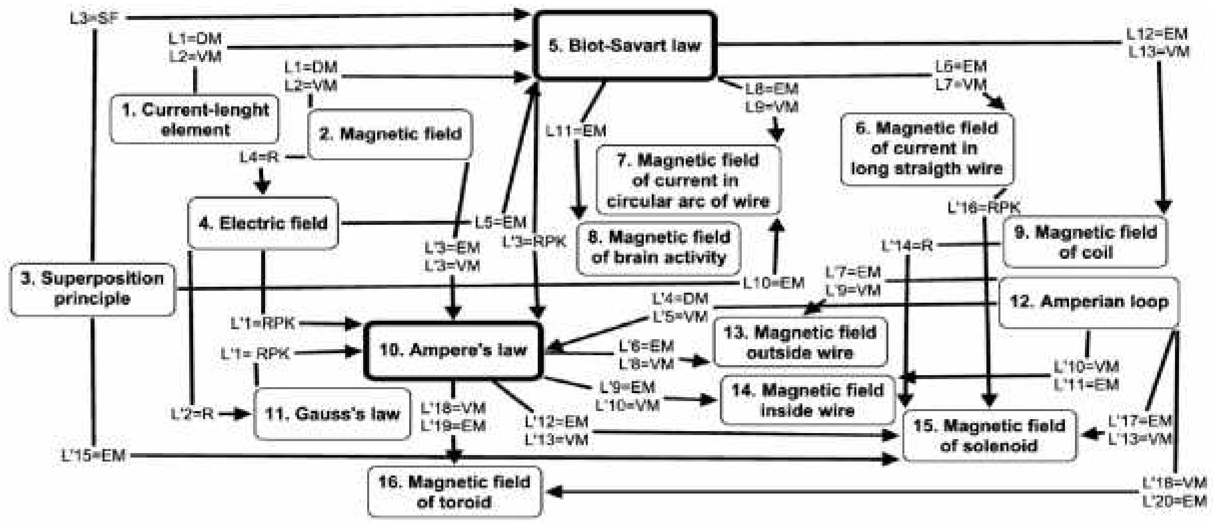

Fig 3. Concept map representing the knowledge organization of the textbook of HRW.

In contrast to FLS, Biot-Savart law is presented before Ampère's law in the textbook of HRW. There are only two dead end nodes in this concept map. There are incoming and outgoing links to Biot-Savart law as well as to Ampere's law. There are also some cross-links in this organization. As Fig 3 shows, knowledge organization of HRW includes many hierarchical levels. HRW describes high interactive process that includes some cross-links. Besides, the knowledge organization of HRW consists of many incoming and outgoing links. HRW includes only two disjointed concepts. Therefore, the knowledge organization of HRW is flexible and interconnected.

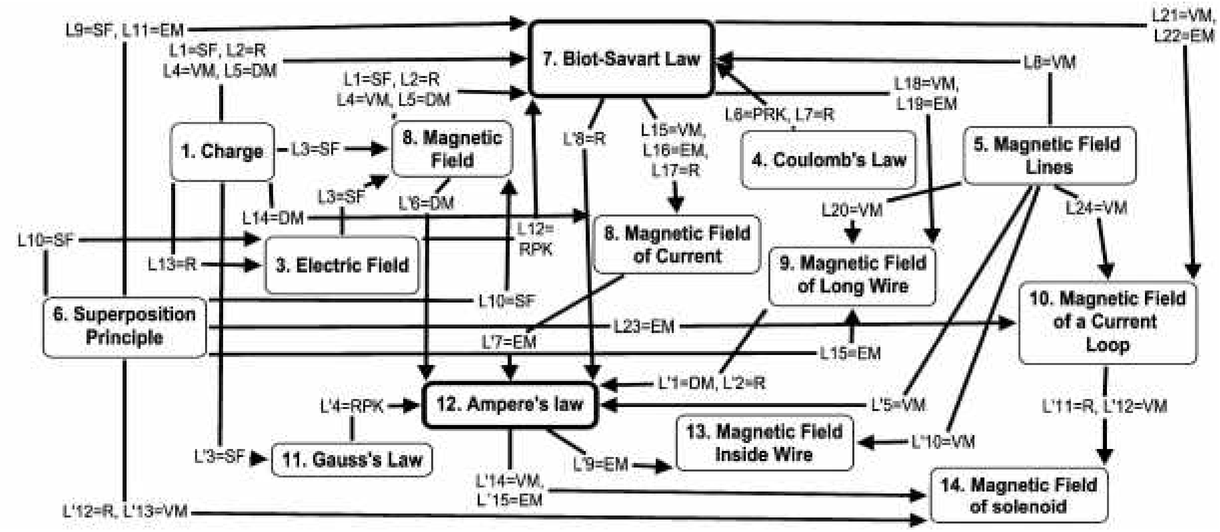

Fig 4. Concept map representing the knowledge organization of the textbook of Knight.

The organization of this concept map is somehow similar to HRW. In other words, there are some incoming and outgoing links to both core concepts. However, comparing HRW, there are more cross-links comparing to HRW. As Fig 4 shows, knowledge organization of Knight contains many hierarchical levels. Moreover, the knowledge organization of Knight is an interactive process that includes some cross-links. The knowledge organization of Knight includes many incoming as well as outgoing links. There is only one disjointed concept in the knowledge organization of Knight. Such an organization has flexible and interconnected structure. The knowledge organizations that are hierarchical and include interactive processes are more flexible and interconnected and therefore they are more beneficial for learning than simple structures.

CONCLUSION AND DISCUSSION

In this study, first the basic elements are specified. Second, a framework to categorize the links between the basic elements has been developed and validated by utilizing experts' ratings (resembles approach developed by Roseman et al., (2010)). Finally, the basic elements and links were presented by using concept maps and the knowledge organization of the textbooks was analyzed on the basis of the topological patterns in concept maps. On a basis of results introduced above, the research questions are answered as follows (the numbers refer to the research questions): 1) the links have different characteristics in the examined university physics textbooks. All textbooks used different types of modelling procedures to link the basic elements. However, the different textbooks used the links very differently. The FLS had only few links compared to other textbooks and the DM were the most utilized link type. In HRW, the link types of EM and VM were the most utilized ones. In Knight, there were substantially more links than in other textbooks and the different link types (especially VM, EM, and R) were utilized in versatile ways. 2) The knowledge organization of FLP has simple structure. As for knowledge organizations of HRW and Knight have flexible and interconnected structures. In conclusion, the knowledge organization of HRW and Knight are in many respects similar what comes to hierarchy and interactive process, and they are very different from the knowledge organization of FLS. Such fundamental differences in knowledge organization are bound to affect the views of the knowledge organization of physics that teachers and students obtain from the textbooks.

Here we have proposed a method to recognize basic elements and links between them within textbooks. We have shown that although basic elements for the same topics in different physics textbooks are similar, the textbooks apply different types, and number of links to connect basic elements and eventually their knowledge organization is different. These differences of knowledge organization are revealed by using concept maps, which show the structural patterns of knowledge organization of textbooks and make the comparison between textbooks possible.

Recognizing the knowledge organization in the textbooks is an important subject in education, which affects learning and teaching. This method might actively engage students to think about the basic elements, links, and finally knowledge organization of the textbooks, and thus promote students' understanding of different topics in textbooks. Moreover, using this method may help students to organize their own knowledge and thus encourage them to understand whether their knowledge is well organized or not. Furthermore, other studies verify the impact of textbooks on teachers learning, as discussed earlier (see Ball & Cohen, 1996; Davis & Krajcik, 2005). The proposed method of this study, which recognizes basic elements and categorizes links, could be applied to analyze the quality of texts. Previous studies discussed earlier (e.g. Roseman et al., 2010) have emphasized the specification of the key ideas and the connections among them within the textbooks, but few of them carried out such investigation. In this study, in addition to recognition of the basic elements in textbooks, we developed a specific framework to clarify the nature of the links that connect the key ideas, basic elements of knowledge organization.

This research is continuing to explore the knowledge organization of university teachers by using the same kind of analysis method that is discussed in this study. The comparison of the knowledge organization of university teachers and university textbooks can reveal interesting aspects having influence in science education and teaching.

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STUDENTS' ACCEPTANCE OF A LEARNING MANAGEMENT SYSTEM FOR TEACHING SCIENCES IN SECONDARY EDUCATION

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Abstract: Learning does not take place only in the classroom. Nowadays, online teaching and learning has become a phenomenon and many believe that e-learning can be the next revolutionary change in education. E-learning is a way of learning supported by Information Communication Technologies (ICT) that makes it possible to deliver education and training to anyone, anytime and anywhere. Our research deals with the implementation of e-learning in the area of secondary education in Greece for teaching natural sciences. The Learning Management System (LMS) called Moodle (Modular Object Oriented Dynamic Learning Environment) was used for the creation of the virtual classroom. Asynchronous and synchronous communication was tried especially among the students, as well as between students and the instructor, aiming at cooperative learning. The main objectives of our study were to analyze the relationship of students' intention to use e-learning with selected constructs such as their attitude, perceived usefulness, perceived ease of use, self-efficacy of e-learning. The Technology Acceptance Model (TAM) is used in order to examine how students receive and how they use the Moodle platform. The positive attitude that is observed towards the model of blended learning and the Moodle platform did not appear to have high cross-correlation between use and intention of use. This fact was verified by the system's log files of students' participation in the attendance of internet courses and by the final acceptance questionnaire. The adoption of an appropriate pedagogical framework is needed in order to engage students and teachers in a LMS for teaching and learning natural sciences.

Keywords: E-learning, Sciences Education, Moodle, TAM, Secondary Education

BACKGROUND

Contemporary studies have focused largely on the examination of students' ideas/perceptions of concepts and phenomena within the field of natural sciences. In the following years, students have to develop a more active role in the educational process, and consequently the student must be the main person in the learning process. Contemporary instructional approaches expect students to be active producers of knowledge (Psycharis, 2011). Information and Communication Technologies (ICT) are considered to be largely applicable for natural sciences as they enable representation of phenomena, foster experimental study and enable the creation of models and problem solving applications (Duit, 1995, Psillos & Niedderer, 2002, Psycharis, 2011).

Offering distance education and using ICT for teaching natural sciences is neither a simple nor easy task. Quality guidelines for e-learning courses are needed (Kidney et al., 2007). Learning Management System (LMS) is a software platform for managing a coherent educational electronic system. In particular, through LMS the management of electronic classes and the educational material in general is made possible, such as developing classes through the platform authoring tools, introducing predesigned classes, and modifying, enriching or deleting their content. Monitor data are available to platform administrators and the teachers of the classes. The development of distance learning systems along with technological advancements enables the creation of a new dynamic technology in e-learning. Users' registration can thus be automated and access to classes can be controlled. Users' actions can be monitored from the moment they enter the platform to the moment the exit the system. This pedagogical methodology has to be near to the constructivist educational model (Martin-Blas & Serrano-Fernandez, 2009).

Moodle (Modular Object Oriented Dynamic Learning Environment) is an electronic learning environment (Learning Management System, LMS) which created in the 1990s by Martin Dugiamas, specializing in Computer Assisted Education (CAE). The development of Moodle was based on social constructivism emphasizing the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding (Park, 2009). The present research was based on the use of Moodle 1.9.5 in teaching natural sciences in secondary education.

There are theoretical models that attempt to explain the relationship between user attitudes, perceptions, beliefs, and eventual system use. These include the Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), and the Technology Acceptance Model (TAM). Among these, TAM, proposed by Davis (1986) seems to be the most widely used by researchers. It is a model which explains the adoption behavior of computer systems by the users and calculates the level of acceptance. Figure 1 depicts TAM's three phases (Davis, 1986).

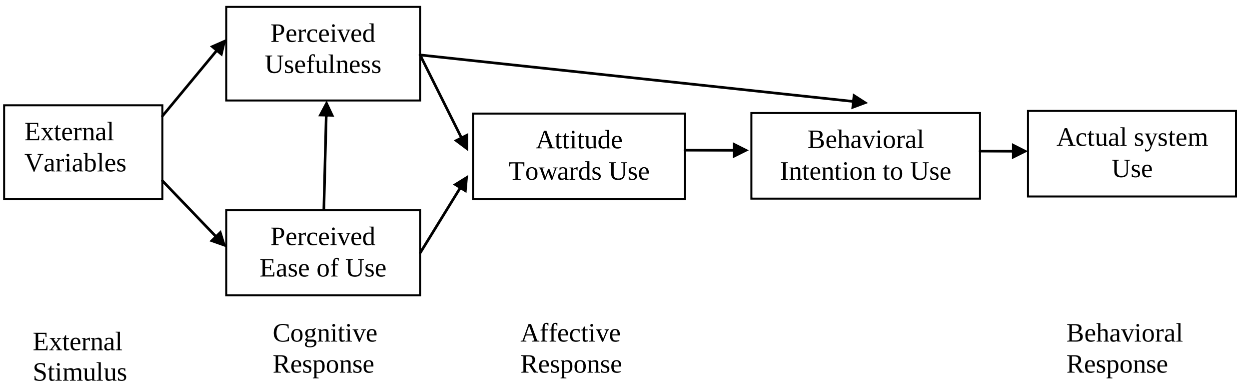

Figure 1: The three phases in TAM: Cognitive, Affective, Behavioral (Davis, 1986)

We used TAM for evaluating the Moodle platform in the framework of a course in natural sciences in secondary education in Greece. The TAM is an analytical simplification of how functionality and interface characteristics relate to adoption decisions. According to TAM, one's actual use of a technology system is influenced directly or indirectly by the user's behavioural intentions, attitude, perceived usefulness of the system, and perceived ease of the system (Davis, 1993). In TAM, technology acceptance and use is determined by behavioural intention (BI). BI in turn, is affected by Attitude Towards Use (ATT), as well as the direct and indirect effects of Perceived Ease of Use (PE) and Perceived Usefulness (PU). Both PE and PU jointly affect ATT, whilst PE has a direct impact on PU (Davis, 1986, Davis, 1993). TAM also proposes that external factors affect intention and actual use through mediated effects on perceived usefulness and perceived ease of use. Although TAM is considered as a well-recognized model in the field of information systems, little systematic research has been conducted in the LMS context for teaching natural sciences.

Selim (2003) argues that there is a need to investigate TAM with web-based learning. In his study, e-learning refers to pure, web-based, asynchronous learning. For Saadé, Nebebe and Tan (2007) university students' participation and involvement were important for successful e-learning systems. Therefore students' acceptance behavior should be assessed. They suggested that TAM is a solid theoretical model whose validity can extend to the e-learning context (Saadé et al., 2007).

FRAMEWORK AND PURPOSE

Aims of the research

One the main ambitions of our work was to get students acquainted with the model of blended learning as well as the use of Moodle environment. We implemented an on-line course as an extension of the face-to-face courses. We created, developed and applied an interactive learning environment for teaching natural sciences at secondary school level. Synchronous and a-synchronous communication was tried especially among the students as well as between students and the instructor aiming at cooperative learning. In the framework of the present research we explored the relation between perceived usability and actual ease of use of such a system, as well as the views towards a virtual learning environment in the model of blended learning.

Rationale

Students were faced up with time restrictions in school educational programs, the schools' infrastructure, the practical difficulties in computer and internet access and the established teacher-centered model. These limitations and the issues relating to the difficulty of applying an alternative pedagogical framework within the natural school space may be overcome by means of distance learning, through a particular LMS.

Our work examined the extent to which such an interactive platform can be used to eliminate such restrictions. We studied the levels of improvement in students' performance, their views towards the introduction of a LMS in natural sciences and also their levels of participation in interactive classes.

METHODS

This is a case study, and our sample consisted of 25 students (12 boys and 13 girls) of the Second Grade studying the course "General Physics", in a General Lyceum in Greece during the school year 2009-10. The learning level of the participants was characterized from good to excellent, based on the students' grades. One motivation for the students' participation was the awarding for participation in terms of grade, to a maximum percentage of 40% towards the final grade of the participants (60% from class performance and 40% from participation and performance in the LMS). The criterion for the school selection was the fact that it is a typical, district school. As far as the social status of the students is concerned, the majority of them came from agricultural or labour backgrounds (children of workmen or employers in private or public organizations), which corresponds to the vast majority of the economically active population in Greece.

In the first phase, the implementation and application of a scaled weekly plan of classes and activities was studied in the field of electric circuits. In this phase, the installation and organization of the Moodle platform was planned, the requirements with regard to hardware and software material were also determined and finally, the server for the webpage hosting the educational and learning environment, including a computer system for synchronous and asynchronous distance learning, was selected.

In the second phase, the efficiency of educators' intervention was applied and evaluated, based on results from spreadsheets. In addition, the use and response to the educational and learning environment was evaluated by means of the system's log files and the respective response questionnaire. The manner in which the study was conducted was based on the quantitative approach. The spreadsheets and questionnaire on meta-learning experience consisted of closed questions, in true-false and yes-no format.

The final response questionnaire consisted of closed questions, under the Likert evaluation format. The creation of the questionnaire was based on a study of relevance to the research questionnaires, bibliography and online websites. Additionally, Moodle environment is included in COLLES (Constructivist On-Line Learning Environment Survey) questionnaire, the examination of which has been helpful in forming some of the questions in this particular questionnaire. The system's log files include numerical data and picturing the participation (for example, entries to the system per student). The process of the data is based on descriptive, statistical methodology (data presentation in tables and figures). For performance examination in spreadsheets, on the first level, there is the normality test Kolmogorov-Smirnov and the t-test evaluation on dependent samples (performance before and after teaching). In addition, in the criterion Wilcoxon highlighted, rank was used to make the comparison (between performance before and after), in cases where there is a variation in the normality test.

RESULTS

The final questionnaire is examined in terms of validity and reliability. In order to establish the conceptual construct validity of the questionnaire, the factual structure was examined, using the principal components analysis method (Tables 1 & 2).

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,571
Bartlett's Test of Sphericity	Approx. Chi-Square	262,168
	df	136
	Sig.	,000

Table 1: Sample Efficiency

Reliability Statistics

Cronbach's Alpha	N of Items
,552	17

Table 2: Scale Reliability

The evaluation of reliability was based on the internal effect with criteria method, the Cronbach "a" method, the item-item correlation testing and the corrected item-total correlations, in order to evaluate each question under this scale. Data processing was performed using the SPSS program, version 17.

The participation demonstrated that during the experimental application examined by investigation the log files were decreasing. The students' outside school preoccupations (such as educational activities, sports, etc.) result in diminishing free time, which acted as a preventive factor to consistent participation. Students claimed they prefer to surf the internet without particular purpose, including social networking webpages such as facebook, rather than get involved in, or spend extra time on, the subject of physics on the internet. The performance grade (a percentage of 40% of total grade) as a means of motivation and award for participation did not appear to play a significant part. This is clearly due to the recently noted indifference of the students towards subjects of general education and their concentration on routine subjects. The examination system in Greece for entering Higher Education has, therefore, formed particular tendencies and results in similar views and behaviours on the part of the students, as far as ICT are concerned.

Factual correlations (Table 3) in the questionnaire, as answered by the students, show that the Perceived Usefulness (PU) of the System is loosely related to the positive view towards Environment Attitudes (EA) and Collaboration and Teaching Attitudes (CTA), whereas it is not related at all to the behavior towards use or Actual System Use (AS). In addition, Perceived Ease of Use (PE) is not related to positive views towards the system (EA) and its relation to Intention of Use (AS) is limited. Finally, there has been found no relation between positive views towards the system (EA) and Intention of Use (AS). The conclusions as set above have been taken into consideration and have been confirmed in the system's log files (course view) (Figure 2).

Component Correlation Matrix

Component	1 (PU)	2 (AS)	3 (CTA)	4 (PE)	5 (EA)
1 (PU)	1,000				
2 (AS)	-,062	1,000			
3 (CTA)	**-,269**	-,082	1,000		
4 (PE)	**,217**	**-,240**	-,189	1,000	
5 (EA)	**,328**	-,024	-,125	,005	1,000

Table 3: Matrix of factual correlations p<0,01

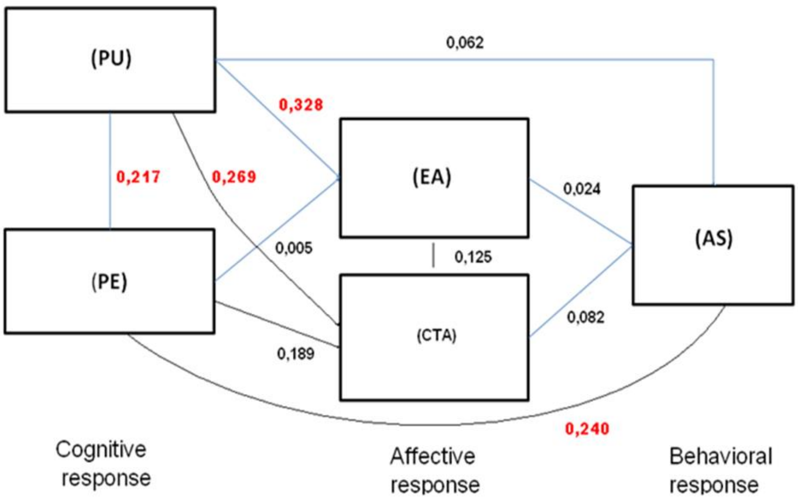

Figure 2: Factual correlation of response questionnaire

The students, in the majority being acquainted with PC use and the internet, can generally learn and use easily an interactive environment, such as Moodle. The collaboration among the students working in groups has had an effect on a third of the students' sample, who changed their decisions towards the correct answer as shown in the study of the answers to the questionnaires on metacognition experience.

CONCLUSIONS AND IMPLICATIONS

In general, students' concentration tends to be positively correlated to their intention to use Moodle for natural sciences. Thus, we should recognize these users as not only system users but also learners. Students can also perceive its usability in terms of the opportunities it can offer. However, the relation between; positive attitudes towards the system, its use and intention of use with perception of its usability, and ease of use is affected on a large scale by other factors. The need for free time, the general views towards school reality and learning in school, the way of life (role-models, values, behaviours) depicted in mass media, the mentality and practices of most educators (with limited exceptions), the lack of team-working experience, are all such conditions which require examination in order to establish how much they relate to the success or failure of e-learning.

The mode of teaching natural sciences and other subjects in schools is not oriented towards team-building learning activities and as a result the students' levels of collaboration are low, since they had never before participated in such an experience. As far as the development, application and function of an interactive environment is concerned, the educator who should attempt such a task shall be faced with difficulties technical and functional in nature from the start. They should be quite certain what is to be used, how to use it, where to publish it, who has the right or the obligation to access it and who controls it. As a consequence, issues such as hosting and platform installation to a larger or smaller extent, can be considered as an "adventurous" and demanding attempt. The knowledge required has not yet been available to Greek educators today by means of any educational programme (Kalogiannakis, 2010).

It should be possible for the use of interactive educational platforms to achieve the aims set, if the students are motivated towards the educational procedure and take full advantage of the possibilities that technology offers to direct and indirect effects within the educational environment. We shall not always consider anything new as something innovative and something to be adopted without control and consideration of other factors.

The choice of an appropriate pedagogical framework, the development, structuring and planning of learning through LMS require that educators who undertake such a project are familiar with ICT, well trained in pedagogical issues as well as in ICT, in order to support the achievement of teaching aims.

The findings of this research are valuable for the assessment of e-learning services in secondary education for teaching natural sciences which will pave the way for future improvement. Our findings should be interpreted within the limitations of a small-scale exploration study and more systematic research is needed. This type of research needs to be implemented in other e-learning circumstances or infrastructures. Future studies should also investigate the role of adding other variables such user experiences and user characteristics to those originally employed in the model. Apart from careful planning and determination of aims, it is vital that certain factors should be taken into account, including educational staff, material and procedures.

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A GAME IN THE CLASSROOM: WHAT DO STUDENTS LEARN?

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Abstract: This paper describes an empirical study relating to the use of a serious game in learning how to establish the chronology of geological events. This research involved 61 16-17 year-old students. The students' challenge consisted in reproducing different images of geological cuts with *Chronocoupe*, a game that simulates the consequences of geological events. The research is based on the *Theory of Didactical Situations* (Brousseau, 1986) and recent research in the field of the use of *serious games* for educational purposes (Egenfeldt-Nielsen, 2010). It aims at addressing the following questions: (a) Which elements should be taken into account in designing the game in order to induce the learner/gamer to engage in epistemic activities? (b) What do students learn when they succeed in the game?

The digital records of students' usage of the game allows one to draw behavioral and epistemic models of students (Wenger, 1987). Data sources of the study include the results of a test to assess students' capacity to determine the chronology of geological events as well.

The study shows that the design of the software must take into account that the students primarily use a trial and error strategy and that they are reluctant to shift to a strategy based on the analysis of the images to be reproduced. The study also shows that the students learn procedural knowledge, but they are not aware of the principles that they use when they are asked to establish the chronology of geological events.

Keywords: serious game, geology, science learning, epistemic modeling

1) BACKGROUND, FRAMEWORK AND PURPOSE

As gaming is one of the of the most popular occupations of youths, an increasing number of science teachers integrate serious games – *e.g.* digital games designed for educational purposes - into their teaching practices. However, few empirical studies have been carried out to explore the value of serious games for science education. It can certainly be said that digital games facilitate learning, but the evidence for saying any more than this is weak as most studies focus on the impact of game-based learning on students' motivation (Egenfeldt-Nielsen, 2010).

Our research aims at producing empirical evidence for the effectiveness of game-based learning for science education. Our work is grounded on the Piagetian hypothesis that states that learning is adaptive. Learning is considered to be an adaptive process (Piaget & Inhelder, 1966), the learner/player incorporates the game experience into an already existing framework (*assimilation*), while reframing his/her mental representations to fit new experiences (*accommodation*). Our work is also based on the *Theory of Didactical Situations* (TDS) (Balacheff, Cooper, & Sutherland, 1997). According to Brousseau, there is a strong link between problem solving (in a learning situation), and knowledge (as an instrument to mastering the situation). The learning process results from interactions between the learner and a *didactical milieu* (*Ibid*.). The *didactical milieu* encompasses all the elements of the situation with which the learner deals during his/her activity. These elements are concrete, symbolic or human.

In our research, the TDS is employed to design the game (as a *didactical milieu*) and the setting of the learning session. The session is an *a-didactical situation* (*Ibid*.). This means that the objectives of the teacher are hidden, while the activity appears driven by exploration. As a result, the learner doesn't need to interpret the expectations of the teacher to succeed in the game (Ahuja, Mitra, Kumar, & Singh, 1995). The theory is also used to analyze the outcomes of the study by focusing on interactions between the learner/gamer and the game.

In this paper we address the following questions:

- Which elements should be taken into account for game design in order to permit the learner/gamer to be engaged in epistemic activities?
- What do students learn when they succeed in the game?

2) METHODS AND SAMPLES

Chronocoupe is a *serious game* designed for geology teaching. It is possible to download the software for free on the website of the author. The interface of the game (fig. 1) shows an image of a geological cut that can be generated by clicking the *event-buttons* (seven different geological events are implemented). Clicking an *event-button* modifies the image. For example, clicking the sedimentary button adds sedimentary layers and clicking the *fold-button* folds all the previous geological features. The game consists in reproducing the images of five geological cuts. The learner/gamer can compare his/her images with the images to be reproduced at any moment by clicking on the image. He/she is allowed to cancel only the last click, but a *restart button* allows him/her to restart the game. It is thus very difficult to reproduce an image by using a trial and error strategy.

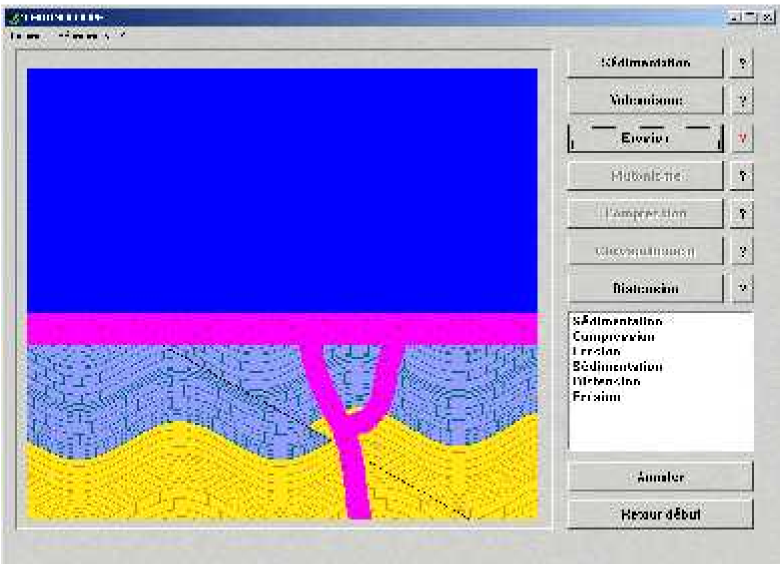

Fig. 1: *Chronocoupe*

The learner/gamer's success depends on his/her capacity to determine the geological event chronology of the different images displayed by the game. The chronology can be determined by applying the principles of stratigraphy. The *principle of superposition* states that, given normal conditions of deposition, new sediment layers deposit on the top of previous sediment layers. The *cross-cutting relationships principle* states that the geologic feature which cuts another is the younger of the two features. *Chronocoupe* is both a serious game and a simulation that simulates the forming of geological features and allows the player to explore the consequences of the simulation.

The experimentation was held with a sample composed of 61 students in the second year of upper secondary school in France (ISCED level 3A-16/17 years old). Each student used the computer individually. The students were asked to reproduce five images of geological cuts. The images were similar in terms of difficulty to reproduce. Different geological concepts, such as sedimentary process, magmatism and tectonics, were taught during previous teaching sessions.

The methodology of the research is based on the recording of the students' clicks (log files) to model each individual student's behavior. The log files are used to draw a chronogram for each student. This was done with a Microsoft Excel file designed by the author. A chronogram is a time line with colored bars that indicate the different clicks during the experimentation (fig. 2). Three indicators are used to compose a behavioral and epistemological model (Wenger, 1987) of the learner/gamer:

(a) The time devoted to reproduce an image indicates students' capacity to determine the chronology of geological events and to apply the principles of stratigraphy;

(b) The time devoted to the observation of the image to be reproduced is an indicator of the students' strategies. A short time indicates that the student doesn't base his/her chronology on a precise observation of the image, adopting a trial and error strategy instead.

(c) A high number of clicks of the restart button also indicates a trial and error strategy.

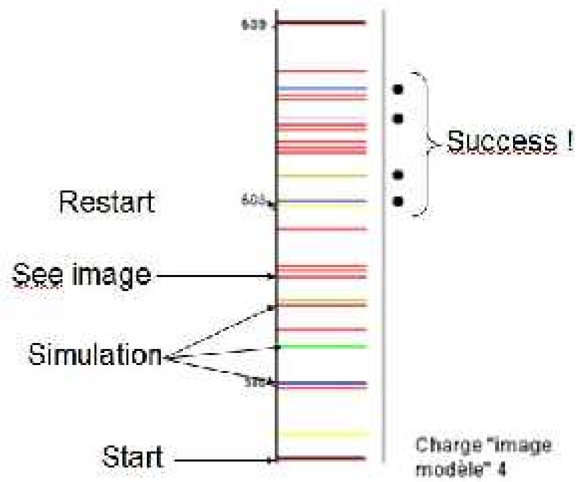

Fig. 2: Extract of a chronogram

At the end of the activity, the students were asked to take a test that consisted in determining the geological event chronology of an outcrop's image and to answer a short questionnaire. Due to difficulties during data gathering, only half of the students answered the questionnaire, but the log files of 42 students were recorded and analyzed.

3) RESULTS

a. Students' capacity to reproduce the images

The average time devoted to reproduce the images (fig. 3) decreases over the course of the experimentation from a maximum of 4 minutes 12 seconds for the second image to 1 minute 36 seconds. Furthermore, inter-personal variability decreases. This result can be interpreted as the development of the capacity of the students to reproduce the *images* and the homogenization of this capacity for the whole sample of our study.

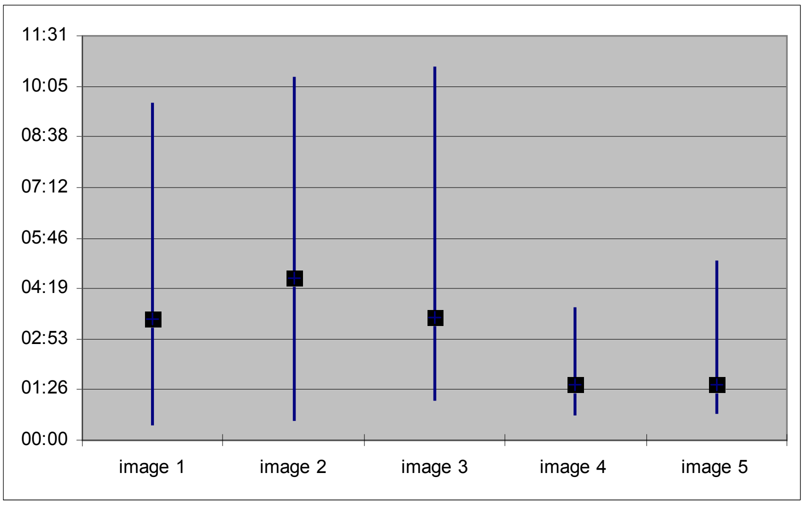

Fig. 3: Average time for the different images

b. Students' strategy shift

Regarding the strategies adopted by students, the comparison of two case studies, the students Elodie and Marie, illustrates two types of behavior. Marie completed the challenge in more than 17 minutes. She failed at reproducing two images. The chronogram shows that she observed the images to be reproduced very often, but during a very short time, usually by a 2 or 3 second glimpse, with 6 seconds as a maximum during the whole session. She very frequently used the *restart button*. All these observations constitute evidence that Marie's strategy consisted of a trial and error strategy, mostly based on chance. This was confirmed by her answers to the questionnaire. The short time devoted to the observation of the image to reproduce indicates that she was not engaged in a precise identification of the clues in the picture that can be used to determine the chronology. In Elodie's case, the session ended in approximately 11 minutes and she succeeded in reproducing all the images. During the first part of the session, Elodie's chronogram is similar to Marie's chronogram: frequent clicks on the *restart button* and short glimpses of the images to be reproduced. In the second part of the session, Elodie changed her strategy. The time devoted to the image observation was longer, 16 seconds as a maximum (for the last image) and the use of the *restart button* was rare (none for the last image). Her strategy seems to be based on a precise analysis of the image. The evolution of the average number of clicks on the *restart button* for the whole group shows that this use decreased during the session. This shows that a majority of students shifted a trial and error strategy to a strategy based on the use of the principles of stratigraphy. The students' answers to the questionnaire confirm this conclusion.

c. Transfer of knowledge

At the end of the session, 20 students from the 24 who passed the final test were able to identify the chronology of geological events on an outcrop's photograph, but only one of them was able to justify his/her response and 4 gave an incomplete explanation. Playing with the game led the students to learn how to identify the chronology of geological events, but they were not able to articulate the knowledge that they used. When they answered the questionnaire, several students themselves expressed that they were reluctant to consider that they had learned something by playing: "*It was fun, but, without the help of a teacher, one cannot really learn something*". The fact that students are often reluctant to consider that they can learn by gaming has been observed in different studies (Egenfeldt-Nielsen, 2007).

4) CONCLUSIONS AND IMPLICATIONS

The design of the gameplay has a significant impact on the learning process. The strategy used by the students is, at a preliminary step, a trial and error strategy based on chance. The students shift to a strategy that involves the knowledge that has to be learnt, if the design of the software disqualifies this trial and error strategy. Starting from this point, a game, as a *didactical milieu*, can be used by the students to assess their decisions and chosen strategy and, therefore, can help them to be autonomous (Sanchez, 2011). Indeed, being autonomous means that the learner/player gets the opportunity to assess his/her strategy by her/himself and then decide if a given decision or action is relevant or not. Assessing implies getting feedback and it is clear that feedback is a crucial element in a game. Therefore, game-based learning results from interactions and we can state that it is worthwhile to adopt a point of view that considers games as situations rather than artifacts (Sanchez & Jouneau-Sion, 2010). Thus serious games are *spaces of reflexivity*, where the learner/player can assess his/her way of thinking and acting. Starting from this point, the term *serious play* is more relevant than the term *serious game* to describe this type of educational practice.

By gaming, the students can develop scientific knowledge. This knowledge is embedded into the game. The students can play with this scientific model, explore the different consequences of their choices and identify properties of the model. The relevance of the scientific model embedded in a game is an important issue to teachers.

The results also indicate that the challenge faced by the students when playing must be inside their zone of proximal development (Malone & Lepper, 1987; Vygotski, 1934). Not all the students managed to succeed in reproducing the images. The design of the game must take into account the necessity to develop students' self confidence in their capability to achieve the challenge.

Our conclusion is that serious games can be implemented in the classroom to teach scientific concepts. Nevertheless, one should expect the learning to consist mostly of procedural knowledge. Indeed, there is a difference between "trying to master the rules of the game and recognizing the ways those rules structure our perception of reality" (Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006). The students do not develop declarative knowledge without reflection and debriefing (Garris, Ahlers, & Driskell, 2002). Some students failed at reproducing the images because the challenge was too difficult. This result emphasizes the importance of the teacher for helping the students to be aware of the implicit knowledge that they use in a specific situation in order to solve a specific problem. This step, called *institutionalization* by Brousseau (Balacheff, Cooper, & Sutherland, 1997; Brousseau, 1998) and underlined by Habgood (Habgood, 2007), consists in pointing out that the contextualized and personal knowledge used for gaming is universal and scientific.

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INFLUENCE OF CONNECTIVISM ON SCIENCE EDUCATION WITH EMPHASIS ON EXPERIMENTS

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Abstract: The paper presents research results of connectivistic influence on science education with emphasis on experiments. Fast ICT development influences science teaching and learning without us realising this. Implementation of science experiments is also strongly influenced by ICT. Thus a need occurred to examine these connectivistic influences on science education. This study describes a research which focussed on the following issues: identification of connectivistic factors and determination of the extending of their influence on science education; creation of connectivistic educational tools and techniques in science education; implementation of connectivistic education tools and techniques into science teaching and learning and science teachers training. School experiments namely the changes in their form and role in science education came under scrutiny. With the aid of the created research method, the collaborative action research based on ICT efficiency of connectivistic tools and methods in science education was researched and confirmed.

Keywords: action research; connectivism; ICT; science education; science experiments.

1 BACKGROUND, FRAMEWORK, AND PURPOSE

Science education is affected by the fast development of information and communication technologies (hereinafter ICT). The use of computers in the operating of school experiments and processing of observed results has been taken for granted. The Internet is becoming an ever more significant source of information including gaining data from distant laboratories. Records of experiment may be easily taken by digital and video cameras and further computer processed. Special computer software allow for animation, modelling and simulation of experiments. The use of the Internet as a communication network gives the students a whole number of options for information sharing, discussions, common problem solving, etc. We may anticipate creation of other significant ICT applications (holographic projection etc.).

ICT is being used by teachers as well as by students. ICT significantly becomes involved in teaching through the use of projectors, interactive boards, computer processed technology teaching elements including experiments etc. But there are differences between teachers´ and students´ attitudes towards ICT. D. Oblinger and J. Oblinger (2005) describe today's students as the Net Generation (Net Gen), who have grown up with widespread access to ICT and have spent their entire lives surrounded by and using computers, videogames, digital music players, video-cams, cell phones, and all the other toys and tools of the digital age. According to the above-mentioned authors, the Net Generation has some features which are different from previous generations and which affect their education. Here are the ones that influence instruction most:

- The Net Generation often intuitively uses a variety of ICT without an instruction manual so their understanding of the technology may be shallow.
- The Net Generation is more visually literate than previous generations, but because of the availability of visual media, their text literacy may be less well developed than the literacy of previous cohorts. Most students (73 %) prefer to use the Internet to libraries for research and they know how to find valid information on the Web (Online Computer Library Center, 2002). However, they realize that the Web does not meet all their information needs.

- In connection with playing a game or responding the Net Generation sometimes prefers speed to accuracy. They do multitask, move quickly from one activity to another and sometimes perform them simultaneously.
- Most Net Generation learners prefer to learn by doing rather than by being told what to do. Net Gen students learn well through inquiry - by exploring for themselves or with their peers. This exploratory style enables them to retain information better and to use it in creative, meaningful ways (Tapscott, 1998).
- The Net Generation often prefers to learn and work in teams. A peer-to-peer approach, where students help each other, is common as well. In fact, Net Generation learners consider peers more credible than teachers in terms of determining what is worth paying attention to (Manuel, 2002).

Other authors also state that children growing up with modern information technology are fundamentally different from previous generations of learners and express it using special naming such as the Nintendo Generation, Millennials, Digital Natives or Generation Z.

The fact that today's students are named by various above mentioned names brings along unique learning style preferences and worldviews. The above mentioned findings have led to the origin of a new educational theory – connectivism as "a learning theory for a digital age". Its founder, G. Siemens (2005) recommends extending the currently existing educational theories of behaviourism, cognitivism and constructivism. Constructivism as the currently accepted educational theory suggests that students create knowledge as they attempt to understand their experiences. Siemens states that learning is a network phenomenon, influenced (aided) by socialization and technology.

We continue to consider the principles of constructivism in science education fully valid and efficient which is confirmed by researches (Trna, Trnova & Vaculova, 2010) etc. Crucial impulses brought about by connectivism have to be accepted and examined: "Learning is no longer an internal, individualistic activity. Education has been slow to recognize the impact of new learning tools and the environmental changes. The ability to learn what we need for tomorrow is more important than what we know today. When knowledge, however, is needed, but not known, the ability to plug into sources to meet the requirements becomes a vital skill. As knowledge continues to grow and evolve, access to what is needed is more important than what the learner currently possesses" (Siemens, 2004). Returning back to the features of today's learners it is possible to recognize the reflection in the first principles of connectivism which were established by G. Siemens:

- Learning and knowledge rests in diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in non-human appliances.
- Capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning.
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate, up-to-date knowledge) is the intent of all connectivistic learning activities.
- Decision-making is "itself" a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision (Siemens, 2005, p. 5).

Science education is also influenced by connectivism and it would be suitable to examine possible connectivistic influences on science and technology education. Our research is concerned with this problem and is focused on the impact of experiments.

2 RATIONALES

Today science education plays an important role in educational systems and in many systems it has the goal of enhancing scientific literacy in students (American Association for the Advancement of Science, 1989), but the interest of students in science has been significantly decreasing. This negative situation has many causes and factors but based on the above mentioned text the way science is taught in schools and different learning style of today's learners are the main ones. In this context it is necessary to consider how to change teaching methods and increase students´ motivation for science. This study is a start towards alleviating these factors, and also increases the familiarity of ICT use for collaborative work among teachers and trainers across the world. Our core idea is to use ICT for the dissemination and upgrading of ideas, curricular materials and effective teaching methods amongst teachers. Connectivistic ideas of sharing knowledge can be applied even to teachers.

To increase the interest of students in science it is necessary to respect the stated generation differences and understand what they prefer, what they are interested in, how they learn. Like all students, they learn more effectively when taught in accordance with their learning style preferences and when their worldviews are acknowledged. So it is necessary to change teaching methods and materials to accommodate the Generation learners better and to correlate them with improvements in students' attitudes and performances. Therefore the need arose to examine possible connectivistic influences on science education. Our research is focused on the following issues:

(i) Identification of connectivistic factors and determination of extend of their influence on science education.

(ii) Creation of connectivistic educational tools and techniques in science education.

(iii) Implementation of connectivistic educational tools and techniques into science teaching/learning and science teachers training.

To narrow the investigated issue we focussed on the implementation of experiments.

3 METHODS

Teachers need research-based innovative educational methods for the upgrading of their teaching. The motivation of students and teachers in science education is the core of up to date teaching/learning. A very urgent task for educational research is to find appropriate educational methods and tools which have to be implemented into teachers' training and then in teaching/learning science. To monitor the set out connectivistic factors, we used a method of a design-based research. It is a development research. This research differs from other types of researches. Unlike the empirical research, hypothesis and research questions are not determined, but the problem is defined to be solved. Design-based research is a new trend in educational research. The used methodology can be described as a cycle: analysis of a practical problem, development of solutions, iterative testing of solutions, reflection and implementation. This methodology was implemented into our research. The scheme compiled by T. C. Reeves (2006) (see Figure 1) presents a comparison between the design-based (development) research and empirical research.

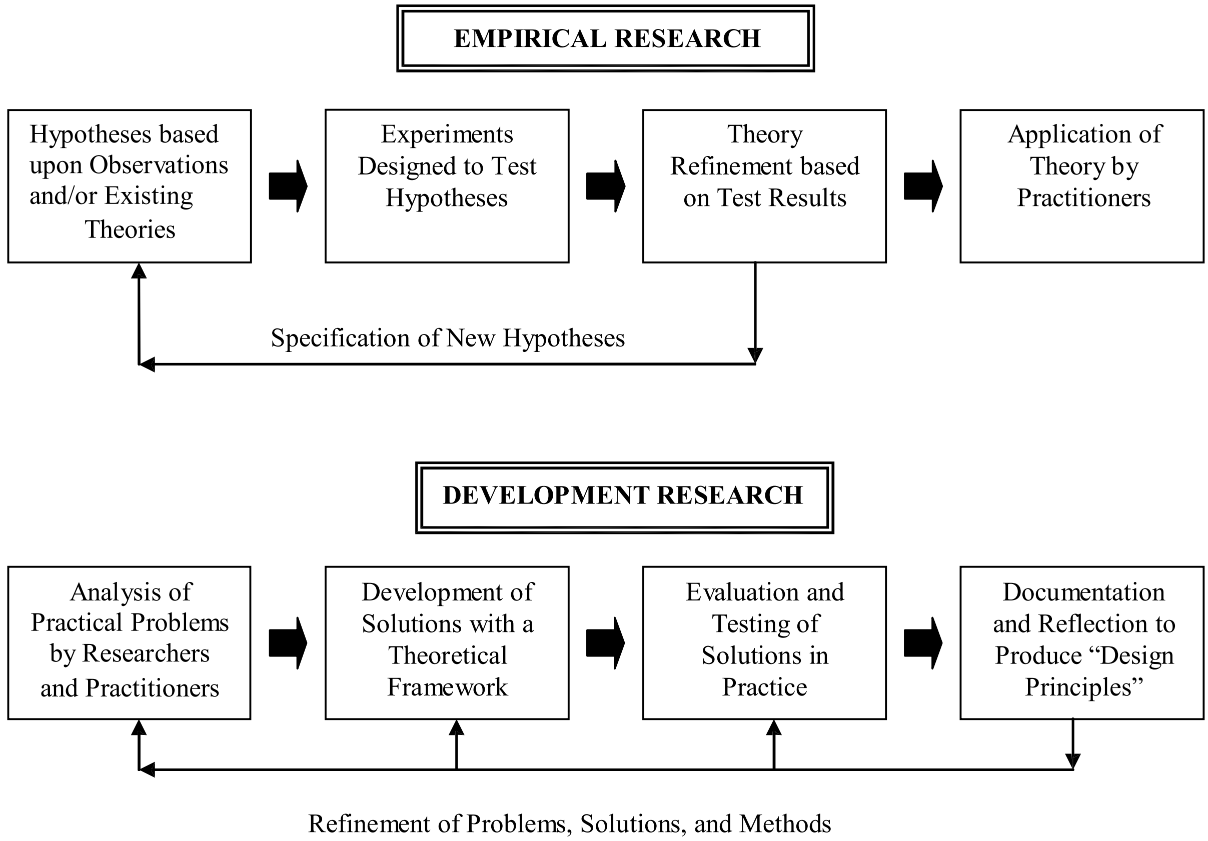

Figure 1. Empirical and development approaches to IT research (Reeves, 2006)

The core of design-based research is to focus on the creation of a new product. This research offers solutions to problems that have only been solved partially so far and relevant instruments and methods (Järvinen, 2004). The main advantage of the design-based research is its close connection with educational practice. Many results of other researchers are considered as separate from practice and are not understood by teachers. The basic principle and advantage of the design-based research is the close cooperation between researchers and teachers, which is a prerequisite of direct use of the research outputs in everyday practice.

The above-mentioned reasons led us to use design-based research to address the issue of the implementation of connectivism into science and technology education. These methods were created within the frame of collaborative action research based on ICT which can be used as a vehicle for international cooperation with effective exploitation of ICT. Sufficient methods/tools for the research objectives were:
(i) Factor analysis
(ii) Didactic analysis and development of connectivistic teaching techniques and tools
(iii) Collaborative action research based on ICT (Trna & Trnova, 2010) for verification of efficiency of developed connectivistic teaching/learning techniques and tools
Data generating methods were available such as through the use of questionnaires, observations, interviews, tests, students' and teachers' portfolios. Collaborative action research based on ICT was carried out in the following form: it was carried out on-line in two classes, one class in the Czech Republic and the second one in Portugal; it was prepared and managed by two cooperating teachers in the Czech Republic and in Portugal; teaching was carried on at the same time with the use of on-line communication (Skype etc.).

4 RESULTS

(i) + (ii) We have discovered several connectivistic factors that show today in the teaching of science and application of experiments: These include namely:

- Computer control of experiments and computer processing of measured data
- Getting of manuals for experiments from the Internet
- Digital recording and web presentations of experiments
- Knowledge sharing and distribution across a network
- Creation of learning structures using networks etc.

We have developed the set of connectivistic teaching/learning techniques and tools applicable primarily in implementation in ICT based collaborative action research:

(a) Application of a single communication language (English): All students have to be acquainted with English terminology also in science teaching (English descriptions of experiments etc.).

(b) Application of ICT communication technologies: Both students and teachers have to command ICT, namely their on-line variants. A web portal with curricular materials has been created which was accessible to students and teachers. The portal contained descriptions of experiments, worksheets, advice to students, etc.

(c) The use of cooperating students' knowledge: both cooperating classes of students made their own experiments the results of which they mutually communicated with belief that they were carried out correctly. Thus, knowledge of others was utilised in a network. In accordance with the ideas of connectivism acquired knowledge can be considered as connective knowledge. Connective knowledge requires an interaction. More to the point, connective knowledge is knowledge of the connection (Downes, 2005).

(d) Creation of communication connections: Students of one class carried out experiments under the on-line instructions of the cooperating partners. Thus the students were creating the skill how to gain the necessary knowledge and skills.

(iii) We used collaborative action research based on ICT. The "action" factor was collaboration among teachers and students from Portugal and the Czech Republic to upgrade teaching and learning using ICT and the innovative school experimentation. Students were involved in the process of learning and were also encouraged to play a teaching role with respect to their peers. The topic chosen was "photosynthesis" by the use of criteria: position of the topic in the curriculum of the countries, importance of the topic for students' cognitive development, and the level of interest for students. The factors considered for the selection of students were age and ability. It was decided that the students should be approximately the same age, promoting an interest to collaborate students. That is why were selected students of intact classes from secondary schools and 15-16 years of age. They needed to be able to communicate in the English language and had skill in the use of ICT (email, ICQ, Skype, and video-conferencing). For this study, teachers prepared a schedule of their own and their students´ activities for each of the collaborative lessons. The teachers collaboratively developed worksheets, power-point presentations, videos, experiments, learning tasks, etc. Reflection was a very important part of this research.

Pre-test and post-test: Pre-test data was gathered about what students already know about the learning focus in order to ascertain those changes in students´ knowledge and skills. Below is one example of pre-test and post-test that focused on one aspect of this work (see Table 1).

Questionnaire: Students completed such a questionnaire that focused on their reflections on this innovative bilateral collaboration and ICT use. Their answers indicate very high levels of both motivation and engagement with the educational process; they learnt a great deal (see Table 2).

Students´ view of teachers´ work in on-line environment and their ability to manage unusual instruction is also very interesting (see Table 3):

Table 1. Pre-test and post-test findings

Pre-test findings:		
Statement	***Correct answers (%) Czech students***	***Correct answers (%) Portuguese students***
In winter, most plants live of the reserves they accumulated during the summer.	56,2	44,4
Post-test findings:		
The plant stores glucose for later use in seeds, roots and fruits.	87,4	81,5

Table 2. Responses by Portuguese/Czech students

In the statements listed below are some of the aspects related to the activities shared with your Czech colleagues. Choose the option which best expresses your opinion.					
N=27/21	*Disagree*	*Partially Agree*	*Agree*	*Strongly Agree*	*No opinion*
The partnership helped you to better understand certain aspects of this topic.	*7%* *0%*	*33%* *29%*	*42%* *47%*	*14%* *19%*	*4%* *5%*
You would have achieved the objectives of this topic better by interacting only with your classroom classmates.	*33%* *29%*	*52%* *29%*	*4%* *29%*	*4%* *0%*	*7%* *13%*

Table 3. Responses by Portuguese/Czech students

Your teacher's performance (on the aspects listed below) contributed to learning the topic in an online environment. Choose the option that best expresses your opinion.					
N=27/21	*Disagree*	*Partially Agree*	*Agree*	*Strongly Agree*	*No opinion*
The teacher showed enthusiasm in sharing experiences between students from both countries.	0% 0%	4% 14%	33% 33%	63% 48%	0% 5%
The teacher demonstrated a capacity to motivate students in this topic.	0% 0%	7% 19%	63% 43%	30% 33%	0% 5%
The teacher demonstrated dynamism to conduct the present activities.	0% 0%	7% 38%	41% 33%	52% 24%	0% 5%
The teacher's interaction and monitoring of students´ on-line work was effective.	0% 0%	11% 14%	33% 48%	56% 33%	0% 5%
The teacher encouraged interaction both within and between groups.	0% 0%	11% 19%	41% 43%	48% 24%	0% 14%

5 CONCLUSIONS

The main outcomes of the research and implementation of connectivistic techniques and tools into science school experimentation:

- Strong motivation of students and teachers by communication with colleagues in other country, new information, applications of new knowledge, new personal contacts etc.
- Exchange of experience between teachers (experiments etc.).
- Teachers' and students' improvement of skills to use ICT and English language.

- Gaining of collaboration competencies between teachers and among students.
- Team collaboration among students and teachers.
- More effective acquisition of science knowledge and skills.

The form and role of experiment in science education has been changing which has to be further examined. With the help of design-based research, suitable teaching tools and techniques have to be created for teachers to implement the experiment in teaching in the most efficient way (Hodson, 1988). We may anticipate a growing importance of simple experiments the students and teachers will creatively work with using ICT. Our research results indicate that students learned with interest, and their knowledge and skills were better than would be expected using standard methods free of connectivism. On this basis, these connectivistic tools and techniques produced very positive outcomes for students and teachers-action researchers.

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THE STATES-OF-MATTER APPROACH (SOMA) TO HIGH-SCHOOL CHEMISTRY: TEXTBOOK AND EVALUATION BY TEACHERS

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Abstract: Chemistry, as a high-school subject for all, should aim to supply students with scientific and chemical literacy (including chemical culture), to cultivate higher-order cognitive skills, and to be a useful, interesting, and enjoyable subject. A chemistry programme for all students in grades ten and eleven (ages 15-17) that was proposed in Greece some years ago, introduces chemistry through the separate study of the three states of matter [the *states-of-matter approach* (*SOMA*)]. There are three major units in the programme, namely: (A) Air, Gases, and the Gaseous State, (B) Salt, Salts, and the Solid State; (C) Water, Liquids, and the Liquid State. Following the proposal, a textbook was written that adopted SOMA. The book was evaluated by four experienced upper secondary chemistry teachers, (and one university chemistry professor)**.** The evaluation examined the following dimensions of scientific and chemical literacy: cognitive domain (learning), affective domain (satisfaction), relevance to students' life (chemistry and life), and higher-order cognitive skills (HOCS). The teachers found the book complete, dealing with many matters, and its level was advanced (difficult in some cases). SOMA was judged very original, having a logical flow of the material, and in general the evaluators liked it. In addition, the book fulfills, in general, the aims of chemical literacy and chemical culture, is relevant to students' life, and it can cultivate HOCS in students. Finally, we note the expressed reservations and suggestions for improvement.

Keywords: high school chemistry, states-of-matter approach (SOMA), chemical literacy, chemistry textbooks, evaluation of textbooks

BACKGROUND, FRAMEWORK, AND PURPOSE

Chemistry is regarded as a difficult subject for students. The intrinsic nature of the subject and the difficulties associated with the process of human learning are held responsible for this difficulty (Johnstone, 2000). Johnstone has proposed the three-level structure of modern chemistry: the *macro* and tangible level, the *symbolic* and mathematical or *representational* level, and the molecular and invisible or *submicro* level. The psychology for the formation of chemical concepts at the submicro level is quite different from that of the macro/'normal' world.

Chemistry, as an upper-secondary school subject for all, should aim to supply students with chemical literacy and chemical culture, to cultivate higher-order cognitive skills/HOCS (such as critical thinking, problem solving, evaluative thinking and decision making) (Zoller & Tsaparlis, 1997), and to be a useful, interesting, and enjoyable subject. There are various levels and expressions of scientific literacy (Shwartz et al. 2006, and references therein). One categorization distinguishes the following three levels: *practical or functional literacy* is the lowest level, and refers to the ability of a person to function normally in his/her daily life as a consumer of scientific and technological products, such as food, health, and shelter. *Civic* *literacy* (or literacy as power) refers to the ability of a person to participate wisely in a social debate concerning scientific and technologically related issues. Finally, *cultural or ideal literacy* includes an appreciation of the scientific endeavor, and the perception of science as a major intellectual activity.

A chemistry program for all students in the tenth and the eleventh grade (ages 15-17) was proposed in Greece some years ago, and introduced chemistry through the separate study of the three states of matter [the *states-of-matter approach* (SOMA)] (Tsaparlis, 2000). SOMA claims to be consistent not only with a *logical* but also with a *psychological* approach to introductory chemistry. It also was conceived so that to deal with many aspects of scientific and chemical literacy.

There are three major units in the programme, namely: A) *Air, Gases, and the Gaseous State*, (B) *Salt, Salts, and the Solid State*; (C) *Water, Liquids, and the Liquid State*. Following the proposal, a textbook was written that adopted SOMA. The aim of this proposal is to present the book as well as the results of its preliminary evaluation by experienced chemistry teachers.

With the first three major units of SOMA, an original approach to chemistry is attempted through the three states of matter. Table 1 outlines the contents of the book.

Table 1: The contents of the SOMA textbook.

UNIT A: Air, Gases, and the Gaseous State A 1 the atmospheric air A 2 atoms and atomic structure A 3 molecules and molecular structure A 4 the chemical reaction A 5 oxygen and inert gases A 6 the ideal gas and its state equation A 7 hydrocarbons and combustion reactions A 8 air pollution, greenhouse effect, depletion of ozone layer **UNIT B: Salt, Salts, and the Solid State** B 1 salt and the crystal structure B 2 salts, metal oxides, and metal hydroxides B 3 molecular solids B 4 metals B 5 solid waste and its management; recycling of solid materials (metals, glass, paper, plastics)	**UNIT C: Water, Liquids, and the Liquid State** C 1 role of liquid state for life C 2 temperature range for the liquid state C3 intermolecular forces (Van der Waals, London) C 4 water - hydrogen bonding C 5 bromine and mercury: the only liquid elements C 6 organic liquid substances and compounds (diesel fuel, petrol, alcohols, ethers, aldehydes, ketones, acids, esters) C 7 solutions, aqueous solutions of ionic compounds, double displacement reactions molarity C 8 colligative properties of solutions C 9 acids and bases - chemical reactions in aqueous solutions C10 drinking water, water quality, water purification, waste water treatment, water pollution, acid rain

The introduction of the gaseous state first was based on the following facts: (a) being the simplest, it is the best understood by scientists; (b) being macroscopically ‘non-concrete’ for most students (a misconception), it is the most suitable prelude to the study of the invisible submicrocosmos of atoms and molecules; (c) the elements and compounds which are, under usual conditions, in the gaseous state have small and simple molecules [we work with only few non-metals (H, O, N, halogens, and noble gases), and compounds (H_2O, O_3, NH_3, NO_x, CO, CO_2, gaseous hydrocarbons, H_2S, SO_2, HCl)]; (d) we start with the covalent bond (Johnstone, 2000; Johnstone, Morrison, & Reid, 1981); neither ions nor the ionic bond are necessary (the ionic bond and the periodic table are introduced in the unit of solids); in the case of the ideal gas, intermolecular forces are absent (but mention of real gases should be made); (e) the study of organic compounds is introduced early (Johnstone, 2000; Johnstone, Morrison, & Reid, 1981). In this way, some integration of inorganic and organic chemistry is achieved. For more information about *SOMA*, see Tsaparlis (2000).

Note that a follow-up course (for the eleventh grade) completes the "*Chemistry for General Education*" course. This course includes the following chapters: (1) overview of organic chemistry; (2) polymers and plastics; (3) medicines (drugs); (4) biomolecules; (6) food; (7) energy; (8) chemistry, the earth, and the space; (9) chemistry as a continuously developing science. (Chapter 7 covers electrochemistry, nuclear chemistry, and alternative forms of energy.)

A sample page from the book is shown in the appendix. An extended excerpt can be downloaded from the following Internet address:

http://www.parsel.uni-kiel.de/cms/fileadmin/parsel/Material/Ioannina/neu1/Salt_7_-SOMA2.pdf

These texts have been translated from Greek into English by the first author of this article.

METHOD

The role of the curriculum is crucial in the educational systems. Textbooks are written in conformity with the curriculum; hence the role of the textbook is also crucial in the teaching process. It is natural then that the evaluation of textbooks is considered as a necessary condition for the upgrading of the provided quality of teaching.

The SOMA textbook was subjected to a preliminary evaluation by four experienced upper secondary chemistry teachers (plus one university chemistry professor). Three of the teachers were male and one female. One teacher had obtained a graduate diploma in science education (this teacher belonged to the research group of the first author).

When the teachers had completed studying the book, we took structured interviews with them, during which they were asked to answer a number of questions concerning their impression, comments, suggestion for improvements, etc. taking also into account the existing state textbooks for chemistry for general education of tenth and eleventh grades. A second group of questions concerned if the book fulfills the aims of chemical literacy and chemical culture, and if cultivates HOCS in students.

The evaluation is in congruence with the main levels of scientific and chemical literacy (Shwartz et al. 2006). In particular, the above questions can be classified according to the following four dimensions: *Cognitive domain* (learning); *Affective domain* (satisfaction); *Relevance* to students' life (*chemistry and life);* HOCS.

A number of extra questions were obtained from the literature and concerned specific aspects of chemical literacy (Shwartz et al. 2006). These referred to (a) general scientific ideas, (b) features of chemistry (key-ideas).

RESULTS

Cognitive domain (learning)

- The teachers found the book complete, dealing with many matters, and its level was assumed to be advanced (difficult in some cases).
- SOMA was judged very original, having a logical flow of the material.
- All liked the integrated coverage of inorganic, organic, and physical chemistry.

On the other hand, there were some reservations regarding SOMA and/or the book:

- The approach was found good, but quite unusual.
- The book contains a number of difficult concepts (e,g. Millikan's experiment, atomic emission spectra, ΔG, enthalpy, phase diagrams, etc.).
  [*Authors' comment:* Most of these are placed inside boxes, and they are not essential – the teacher can skip this material without damaging the flow of the content. On the other hand, their presence provides for fuller coverage and global knowledge.]
- All agreed that the level of the book is advanced, and that it will be difficult for the average student.

Affective domain (satisfaction)

- In general the evaluators liked the book.
- They all liked its format/lay out.

Relevance to students' life (chemistry and life)

The teachers found very good and complete the practical part of the book (dealing with applications and connections to life). In addition, they were asked to comment on the following features were explicitly stated by the researcher during the interviews with the teachers:

- Importance of chemical language for the explanation of everyday phenomena and their uses by people as consumers of new products and technologies, in decision making, and in their participation in a social discussion relevant to issues where chemistry is involved.
- Relations between development of chemistry and social processes.

[*Authors' comment:* These aspects are served in part by the book. More to this should contribute the follow-up course for the eleventh grade.]

Higher-order cognitive skills

According to the teachers, the book can contribute to the development of these skills. However, the lack of questions and problems was judged as a problem.

[*Authors' comment*: The book needs indeed the inclusion of questions and problems that will contribute to the development of scientific literacy and HOCS.]

Specific questions on chemical literacy

General scientific ideas (these ideas were explicitly stated by the researcher during the interviews with the teachers)*:*

- Chemistry is an experimental science.
- Chemists carry out research and propose theories to explain the world.

These ideas can be achieved with experiments that should be included in the book. According to the teachers, there is need that the book is supplied with a practical part (a laboratory guide).

Features of chemistry (key ideas) served by the book. According to the teachers, the following features are served by the book (these features were explicitly stated by the researcher during the interviews with the teachers):

- Chemistry attempts to explain macroscopic phenomena in terms of the molecular structure of matter.
- Chemistry studies the dynamics of changes and reactions.
- Chemistry studies the energy changes that accompany chemical reactions.
- Chemistry uses a special language – a chemically literate person does not have to know this language, but he/she should be able to appreciate the contribution of the chemical language to the development of this science.
- Chemistry contributes to the understanding and explanation of life on the basis of chemical structure and processes in living organisms.
  [*Authors' comment:* This aspect is covered by the biology course - but also note that a chapter on biomolecules is suggested to be included in the follow-up chemistry course for the eleventh grade.]

Finally, the teachers made suggestions for improvements. We have mentioned already the need for addition of a laboratory guide, and of questions and problems. Most teachers thought that more organic chemistry would be necessary. Organic chemistry is dealt with more systematically and more fully in the proposed follow-up course (see above). Of particular interest is a suggestion by the university professor that the Internet is an endless source of scientific information, facts, and data, hence there is no need to burden anymore modern textbooks with details and facts that can easily be found on the Internet; this will contribute to the drastic shortening of text length.

CONCLUSIONS AND IMPLICATIONS

SOMA combines the logic of chemistry with the psychology of learning (Johnstone, 2000). It could provide scientific and chemical literacy (including chemical culture) to all students, as well as make them appreciate chemistry as an interesting and enjoyable subject, and above all help them to realize its usefulness for their future career and life. We hope that *SOMA* has the potential to give school chemistry a new impetus and status.

SOMA is close to a formalist approach to science teaching. It is possible to combine it, however, with other available context-based material. In this spirit, we have combined SOMA with a recent European Union project, namely '*Popularity and Relevance for Science Education for scientific Literacy*' (PARSEL). PARSEL has developed a number of science modules for secondary education that are available freely on the Internet.[1] Two of the modules, one on carbon dioxide and carbonated beverages and the other on salt, could be used within the *SOMA* units on gases and on solids respectively (Tsaparlis, 2008).[2] A third module on water is under preparation, and that will be suitable to use within the SOMA unit on liquids.

NOTES

[1] The PARSEL Internet site is at the following address: http://www.parsel.uni-kiel.de/cms

[2] The SOMA module on carbonated beverages ("The gas we drink: Carbon dioxide in carbonated beverages") is available in English and in Greek. The module on salt ("Salt: the good, the bad, and the tasty") is available in English, in German, and in Greek. These modules are available at no charge at the following Internet address:

http://www.parsel.uni-kiel.de/cms/index.php?id=modules

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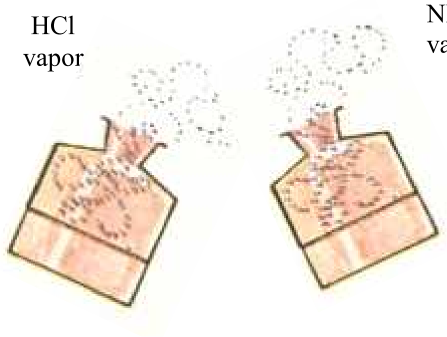
APPENDIX: A sample page from the book from Unit A (Air, Gases, and the Gaseous State)

A 4 CHEMICAL REACTIONS

A 4.1 Chemical changes – Chemical reactions

Often when we bring into close contact between themselves one or more substances (often under the usual conditions of temperature and pressure, but also in different conditions, e.g. higher temperature and/or pressure) one or more changes take place. As a result, one or more new substances are formed, with simultaneous disappearance of part or of the whole of the starting substances. As an example, if we bring into contact gaseous *hydrogen chloride* with gaseous *ammonia*, a new substance is formed, namely the solid *ammonium chloride*:

$$HCl_{(g)} + NH_{3(g)} \rightarrow NH_4Cl_{(s)}$$



The above change is called **chemical change** or **chemical reaction.** A single substance can also undergo a chemical change; for instance, gaseous *hydrogen iodide*, if heated at 550^{o}C in a closed vessel, decomposes into its constituent elements, *hydrogen* and *iodine*:

$$2HI_{(g)} \rightarrow H_{2(g)} + I_{2(g)} \text{ (at 550}^oC)$$

The starting substances are called the **reactants**, while the new substances are called the **products** of the reaction.

There is also the case that a chemical reaction between certain reactants not to take place under usual conditions, but to take place when another substance is present in small amount in the reaction mixture. This extra substance does not change itself during the reaction – it simply makes the reaction possible by its mere presence. As an example, a mixture of oxygen and hydrogen remains unchanged for ever, but reacts vigorously in the presence of platinum (Pt), forming water.

$$2H_{2(g)} + O_{2(g)} \xrightarrow{Pt} 2H_2O_{(l)}$$

In this case, we say that *the platinum **catalyzes** the reaction/**acts catalytically** / is a **catalyst** for the reaction.*

In a chemical reaction, an *interaction* takes place between the molecules of the reactants. The result is that the molecules of the reactants change (by *re-arrangement of the atoms*) into the molecules of the products.

COMPARATIVE EVALUATION OF LOWER-SECONDARY PHYSICS TEXTBOOKS: THE ROLE OF SCIENCE EDUCATION

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Abstract: We examined in actual school practice the effectiveness of an experimental non-standard introductory book to physical science (physics and chemistry) for the seventh grade (first grade of lower secondary school in Greece). The book has been written by science-education researchers, on the basis of principles of science education. In particular, we compared the performance in a relevant test of an experimental group of students (N_1 = 50) who were taught two physics lessons (on the 'force' and on the 'weight of a body') from the above book, with the performance in the same test of a control group of students (N_2 = 50). who were taught the same topics from the standard eighth-grade physics school book. The study was carried out in four eighth-grade classes of two urban lower-secondary Greek schools. The statistical analysis showed that the non-standard book assisted students more in understanding the taught science concepts. However, due to the marginally small sample size and the very limited number of taught topics, the finding should be considered as a preliminary one.

Keywords: physics textbooks, evaluation of textbooks, science education, force, weight

BACKGROUND AND FRAMEWORK

Teaching can be considered a special form of communication and interpersonal relations between the teacher and the students. The role of textbook is crucial in the teaching process. It ensures this communication and contributes more to the growth of interpersonal relations in the classroom than other teaching tools, such as transparencies, experiments, video, PC, etc. (Armbruster & Anderson, 1991).

The evaluation of textbooks is considered as a necessary and sufficient condition for the upgrading of the provided quality of teaching. However, even though the textbook remains the most important teaching tool, it has not gained its proper place either in the relative research literature or in the educational discussions (Bandura, 1986). On the other hand, the results from relative work (Costa et al., 2000) indicate a limited knowledge on the part of the secondary school teachers about the findings of educational research.

Rationale and Purpose

According to the implications of science education research, modern pedagogy should encourage: (a) the active and constructivist teaching and learning; (b) meaningful and conceptual understanding; (c) the development in students of practical abilities; (c) the connection of science with everyday life; (d) a spiral curriculum; (e) the cultivation of higher-order cognitive skills, such as critical thinking. In principle, the application of such instructional methodologies is primarily the job and responsibility of the teacher, and not so much of the textbook. However, to aid the teacher in this job, and considering the limited awarenees of educational research by secondary school teachers (Costa et al., 2000), two of the authors of this article, who are active researchers in science education, decided to prepare the experimental material for this programme in the form of a complete textbook, containing experiments, theory, questions, and problems (Tsaparlis & Kampourakis, 2003).

To our knowledge there is only one international physics book that is based on the learning-by-inquiry model, namely the American textbook "*Physics by Inquiry*", written by L.C. McDermott and her physics education group at the University of Washington (McDermott, 1996). However, we had not consulted and threfore not followed this textbook in writing our own textbook. Our book is entitled "Introduction to physical science" (physics and chemistry) for the 7th Grade" (first grade of lower secondary school in Greece), and is based on principles of science education. Table 1 provides ten basic principles that were adopted in writing the textbook (for details see Tsaparlis & Kampourakis, 2000). The book was written, tested, and evaluated some years ago in the context of the project SEPPE of the Greek Pedagogic Institute. The reader can see an example lesson ("Chemical reactions in aqueous solutions", translated from Greek into English by the first author) in the Supplementary Information/Part 3, to a paper by Tsaparlis et al. (2010) or directly at the following web address:

http://www.rsc.org/suppdata/rp/c0/c005354f/c005354fesi.pdf

In this work, we compare the above book (henceforth called 'experimental book" (EB) against the standard lower-secondary school physics textbook for the 8th grade (school book, SB) (Antoniou et al., 2007). At the outset, we must emphasize that by this work we do not intend to check if the one book is superior to the other; after all, we only used selective topics and a particular test; in addition, due to the relatively small sample size and the very limited number of taught topics, the findings should be considered as preliminary.

Table 1: The ten guiding principles in the writing of the textbook.

1. The spiral curriculum.	6. Scientific rigor - correct use of language.
2. Use of experiments, especially experiments that will be carried out by groups of pupils.	7. Connection of science with everyday life and applications - Development of environmental conscience.
3. Focus on meaningful learning - discouragement of rote learning.	8. Active and inquiry forms of learning.
4. Emphasis on simplicity of phenomena and concepts - priority given to concrete examples – delay of treatment of the abstract concepts of molecules and atoms.	9. Taking into account of students' alternative ideas and misconceptions (constructivist teaching).
5. Delay of representations with chemical formulae and equations.	10. Contribution to students' cognitive development, as well as encouragement of critical thinking.

METHOD

Two Greek urban schools participated in the study (N_1 = 50 N_2 = 50). In each school, the natural class physics teacher taught two lessons (on the 'force' and on the 'weight of a body') from the EB to an intact school class (experimental class, EC); the same teacher taught the same topics from the SB to a different intact class of the same school (control class, CC). The EC and CC were about equivalent, as advised by the class teacher, and as checked by students' average achievement in the first-term physics test. After the teaching, the students of both classes in each school were given the same test for the same period of time (about 20 minutes). Students' answers were graded by the second author. The physics test is shown in the appendix, and consists of three questions. Questions 1 and 2 were taken from the EB (but had been removed from the students' text), while Question 3 was taken from the SB. All questions were demanding and were selected because they tested both for knowledge and conceptual understanding. The small number of questions was directed by the fact that the teachers had only a limited time (20 minutes) to administer the test, because of limited overall available instructional time.

Internal consistency of the test was checked by calculating Cronbach's alpha coefficient. The alpha values were 0.658 for the SB, 0.710 for the EB, and 0.702 for the total student sample. Values form 0.6 to 0.7 are assumed as showing moderate internal consistency, while values higher than 0.7 show higher consistency (Cortina, 1993).

Reliability of the marking was checked by having three experienced teachers first agreeing on a marking scheme and then each one of them marking 15 randomly selected papers. The non-parametric *Spearman* rho correlation coefficient gave values ranging from 0.852 to 0.972. The 15 papers were also marked independently by the researcher who marked all the papers. The correlation coefficient between the researcher's marking and the average marks of the three other markers ranged from 0.849 to 0.983.

Normality of the distributions was checked by means of the Kolmogorov-Smirnov test. It was found that normality was not followed when taking separately each question, but it was followed when taking all questions together. As a consequence, for the comparison of the achievement in all three questions we used the student *t*-test, while for the comparisons of the achievement in each separate question we used the Mann-Whitney non-parametric test.

All statistical calculations were made by using SSSP.

RESULTS

Figure 1 is a box-and-whiskers plot of student performance per question and the average mark of the three questions for the control and the experimental classes. Every box depicts the range of the 50% of middle marks, leaving out the top and bottom 25%. The horizontal line inside a box shows the median. The whiskers show the highest and lowest mark.

Table 2 has the average marks and the corresponding standard deviations for the four classes, the three questions and the average of achievement in the three questions. For question 1 there is a 26.4% difference in favor of the experimental group. For question 2 this difference is only 2.2%, while for question 3 it is 6.8%. Taking the average of the three questions, the experimental group is superior by 11.8%. For the comparison of achievement in the totality of the three questions, the student *t*-test assumed the value of 2.691 ($p = 0.008$), by using both the hypothesis of equal and unequal variance (Table 3). For the comparisons of the achievement in each separate question, the non-parametric Mann-Whitney test gave Z-values equal to 3.586 for question 1 ($p < 0.01$), 0.764 for question 2 ($p > 0.10$), and 3.082 for

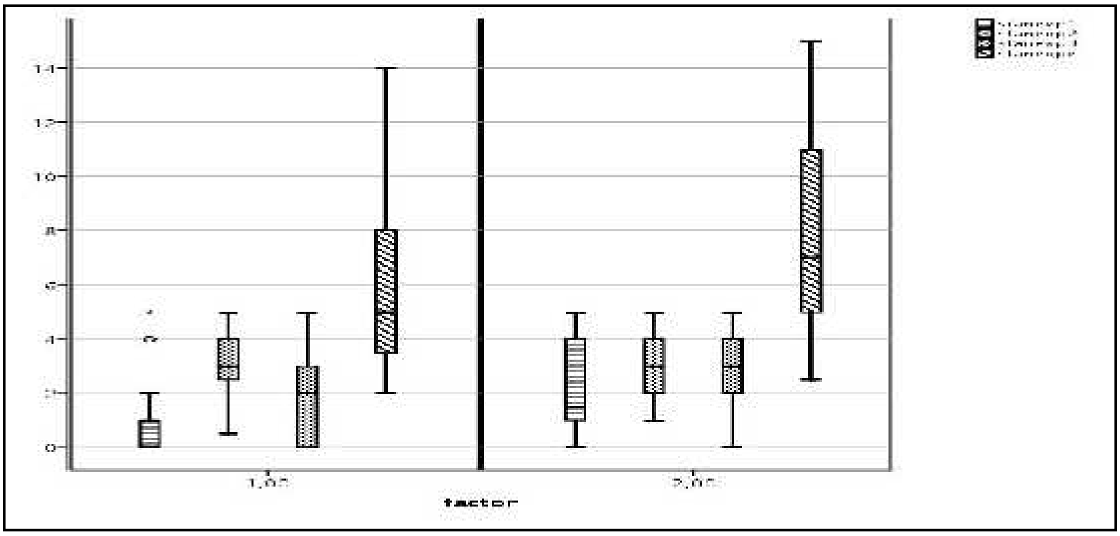

Figure 1. Box-and-whiskers plot of student performance per question and the average mark of the three questions for the control (left-hand side) and the experimental (right hand side) groups.

Table 2: Student achievement per class and per question (mean mark and standards deviations in parentheses (maximum 100). (EC: experimental class; CC: control class)

Class	*Question 1*	*Question 2*	*Question 3*	*Average of three questions*
EC1 (N=25)	40.0 (39.2)	68.0 (24.0)	41.6 (35.6)	49.9(25.9)
EC2 (N=25)	52.8 (37.0)	56.4 (22.8)	47.2 (31.6)	52.1 (22,0)
Total ECs (N=50)	**46.4 (38.2)**	**62.2 (23.8)**	**44.4 (33.4)**	**51.0 (3.60)**
CC1 (N=26)	13.0 (21.8)	65.0 (19.8)	42.4 (30.6)	40.1 (18.2)
CC2 (N=24)	27.6 (32.2)	54.6 (21.8)	32.6 (31.6)	38.2 (21.3)
Total CCs (N=50)	**20.0 (28.0)**	**60.0 (21.2)**	**37.6 (31.2)**	**39.2 (19.6)**

question 3 ($p < 0.01$) (Table 4). In questions 1 and 3, the differences are statistically significant in favor of the experimental classes at the 1% significance level (s.l.). In question 2, the difference is not significant. For the average of the three questions, the difference is significant at the 1% s.l.

DISCUSSION AND IMPLICATIONS

Question 2 asked students to just draw vectors for the exerted forces, but did not require explanations. On the contrary, questions 1 and 3 asked students to explain their answers, hence they were more demanding. This must have contributed to the considerably higher average student marks in question 2.

Table 3: Comparison of performances for the average of the three questions of the experimental and the control group ($N_1 = 50$, $N_2 = 50$) by means of the *t* statistic.

	Levene test for equality of variances		*t-statistic*		
	F	*Sign. level*	*t*	*d.f.*	*Sign. level*
Hypothesis of equal variances	3.945	0.050	2.691	98.00	0.008
Hypothesis of unequal variances			2.691	94.15	0.008

Table 4: Non-parametric Mann-Whitney test for the separate questions.

	Question 1	Question 2	Question 3
Mann-Whitney U	750.5	1207	811
Z	-3,586	-0,301	-3,082
Asymptotic significance level	0,000	0,764	0,002
Statistical significance	p<0,010 (S)	p>0,10 (NS)	p<0,01(S)

Question 1 had an added problem: from the placement of the three boys in the picture many students made the interpretation that the one boy on the right-hand side was pulling against the force of the two other boys. This is supported by the analysis of interviews taken by a number of students.

In the average of the three questions, there is statistically significant superiority of the experimental classes at the 1% significance level. We conclude that the approach to the concepts of force and weight by the experimental book helped students of the experimental classes more than the approach of the school book.

Finally, we must point out a number of limitations of this study. We only used selective topics and a particular test. Also, due to the relatively small sample size and the very limited number of taught topics, the findings should be considered as preliminary ones. Further study is needed, with more topics, more schools, and more teachers. In any case, we must emphasize that we do not claim by any means that the experimental book (of which authors are two of the authors of this article) is superior to the school physics book for the eighth grade. The authors of the school book are certainly capable and enthusiastic teachers and authors and among them are teachers who have studied physics education. In addition, the experimental group was written with a certain approach which has apparently affected the choice of the particular questions used in this study. If we had used a different test the outcome could have been different. We call the readers therefore to take the above limitations into account in interpreting the findings of this study. Further research is needed, which would include more lessons, taught by many teachers and in many schools.

In conclusion, the current aims of science teaching in secondary schools can be served better by textbooks that employ methods and approaches that are supported by the findings of science education research. This requires the use of a multitude of methods and approaches. The experimental book that was tested in this study has adopted such an approach and provided evidence that supports the claim that this book contributed to better achievement in the studied topic and test.

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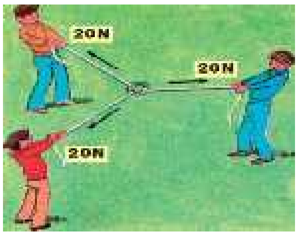
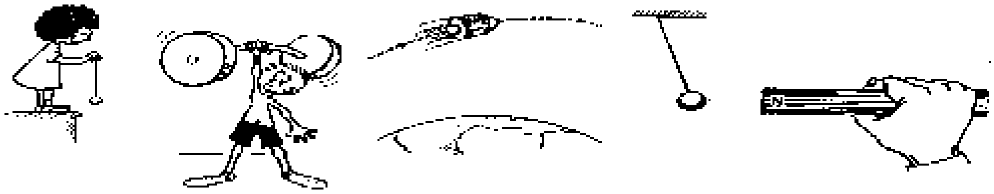
APPENDIX: THE TEST

1. In the figure, each child exerts the same in size force (20 N) on the rope he/she pulls. From the physics point view, are the three forces equal? Explain your answer.



2. In the following pictures, draw the vectors of the forces exerted by: I. The girl's hand on the string. II. The weight-lifter on the weights. III. The earth on the satellite. IV. The magnet on the iron sphere.



3. A schoolmate of yours has this opinion: "A material body has weight when it is on the earth's surface, but it has not weight when it is on the moon's surface". Do you agree? Explain your answer.

WEB-BASED TOOL FOR BASIC CHEMICAL PROBLEM SOLVING IN AN E-LEARNING CONTEXT

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Abstract: In this paper we present a web-based tool which may be used in the didactic treatment of aspects traditionally identified as being a key element in the teaching of chemistry: the solving of simple problems which imply the knowledge of concepts such as mole and amount of substance among others. We have evaluated its use during teacher trainees' first contact with these themes, as a substitute to a classroom session methodology. Good results were obtained. Two homogeneous groups of students with the same level of chemistry knowledge were compared. The group whose learning was based exclusively on the use of the tool without teacher's help, in the end got the same results as the group who received formal instruction from the teacher.

Keywords: Chemical education, E-learning, Web-based tool, Learning object, Problem solving

BACKGROUND, FRAMEWORK, AND PURPOSE

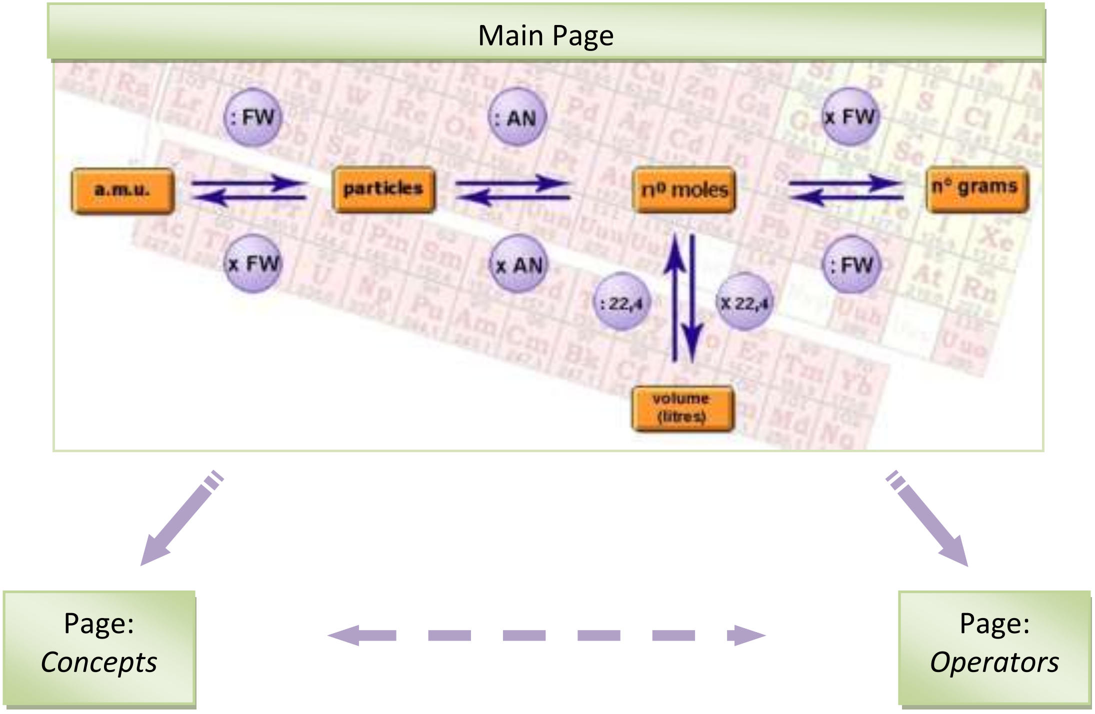
Research in didactics of experimental sciences has traditionally involved the study of the difficulties that certain concepts pose at different educational levels. In the case of teaching chemistry, the key concepts of *mole* and *amount of substance* stand out (e.g., Dierks, 1981; Lybeck et al., 1988; Furió et al., 2002-2006). It seems that the errors in understanding arise from the comparison of the amount of substance with other magnitudes such as mass or volume, or with a number of particles (Avogadro's number). These difficulties are expressed especially in the solving of quantitative problems. Therefore, in many cases the student is incapable of reasoning in terms of proportionality or simple mathematical connections, and learns algorithms or typical problems which he carries out in a repetitive way with little thinking (Gómez-Moliné, 2007; Dahsah and Coll, 2008). Given that generally speaking, overcoming these difficulties depends largely on the direct interaction pupil-teacher, in non-presence teaching contexts the development of materials and methodologies designed to meet that objective is fundamental.

One of the challenges of the application of information and communication technologies (ICT), in the environment of science teaching is the development of adequate teaching tools. Centering on the case of chemistry, the culmination of this evolutionary process is the extended use of hypermedia and of virtual learning environments (e.g., Dori and Barak, 2001; Ardac and Akaygun, 2004; Jiménez and Llitjós, 2008; Maia and Justi, 2009; Own, 2010).

RATIONALE

The tool is a website made up of three multi-linked pages, as is indicated in Figure 1. The main page consists of a concept map in which the main numerical calculations that can be carried out between basic chemical magnitudes, are described. In the nodes of this concept map, concepts such as the number of moles (amount of substance), the mass expressed in grams, the volume in litres, the amount of particles (atoms, molecules, ions….) and the atomic mass units (a.m.u.) appear. These magnitudes are connected by the corresponding operators; formula weight (FW), Avogadro's number (AN) and the coefficient 22.4, which connects the amount of moles and the volume of an ideal gas in standard conditions of pressure and temperature. Each button that appears on the concept map corresponds to a concept or an operator, contains a hyperlink to one of the other two pages, summing up a total of 13 links from the main page (5 with the concepts one and 8 with that of the operators).

Figure 1: Structure of the website *quimicalcul*.



On the page named *concepts*, we include a continuous series of comments for each one of the magnitudes that appear as nodes of the concept map on the *main page*. These comments try to facilitate the understanding of how the concept map works, as well as making the meaning of these concepts more accessible for a beginner student of chemistry.

On the page called *operators*, definitions and comments on the formula weight appear (with atomic and molecular weights integrated within), Avogadro's number (its importance and notes on its historic development), and the coefficient 22.4 (its connection with the ideal gas law). This page also includes on the use of these operators, in the form of small numerical problems already solved, which may be illustrative for the beginner student.

The presentation of the concepts and their connections in the form of just one concept map may bring a series of advantages:

a) In this context, the integration of a series of transformations between magnitudes in which the operators simply multiply or divide may help the student to associate by analogy these calculations with more everyday ones (money, objects which are bought and sold, etc.).

b) Likewise, when they have an overview, the understanding of calculations which require more than one step is made easier. So, for example, the relation between the amount of grams of a substance and the amount of atoms that it contains requires the consideration (explicit or implicit) of two proportions (grams-moles and moles-atoms).

c) The fact that the concept of mole takes up the centre of the concept map, and that the majority of the conversions between magnitudes require "passing through it", is an implicit reinforcement which contributes to the students' understanding of its importance.

However, it would not be satisfactory if learning were limited to correctly carrying out the numerical transformations without a deep understanding of the concepts. So, it is fundamental to have links to the other two pages: *concepts* and *operators*, which would allow frequent consultation of some of the doubtful aspects as well as facilitating access to clarifying examples.

The tool *quimicalcul* has been integrated into a virtual learning environment equipped with the possibilities of the software *moodle* (*ceuandalucia virtual campus*). Therefore, embedded in a content unit, with a group of education students and by means of the platform, so that the teacher carries out his role as guide in learning, is how this tool is adequately used (Figure 2).

Figure 2: Hypertext quimicalcul integrated into the virtual learning environment.

METHODS

Although the preliminary presentation (Vílchez, 2008) and the first details about the efficiency of this tool were moderately positive, we found it essential to collect quantitative data that would contribute to a more objective evaluation. The wide variety and increasing complexity of multimedia resources to teach science make its assessment a task that is not always easy to achieve (Leacock and Nesbit, 2007; Zens et al., 2007; Evans and Leinhardt, 2008). Various approaches may exist according to the interests of different academic communities. In this case, *quimicalcul* is a simple learning object that we have assessed for specific conditions of the educational process.

We have centred on the possibility of using quimicalcul as a substitute to a classroom methodology at the beginning of training in chemistry, in which students come in contact with basic magnitudes and acquire skills in preliminary calculations.

To do this we have used a short, very basic questionnaire consisting of the reasoned solution of 3 small numerical problems which imply the passing of moles to grams (item 1), from grams to moles (item 2) and the passing of grams to molecules (item 3):

If a molecule of gaseous hydrogen (H_2) weighs 2 atomic mass units, consider how many grams a mole makes up.
1) *Calculate the number of grams contained in 5 moles.*
2) *Calculate the number of moles contained in 100 gr.*
3) *Calculate the number of molecules contained in 100 gr.*

Justify the answers.

The questionnaire was given to students enrolled in the course *Natural Sciences and its Didactics* within the Primary Teacher Training program at C.E.S. Cardenal Spínola-CEU (affiliated with the University of Seville-Spain). Students were divided into two groups according to the methodology used. Forming part of one or other group was assigned at random in order to control for variables not related to the intervention:

Group-T (N = 29)**:** In this group students followed a traditional classroom method without using the hypertext *quimicalcul.* The teacher presented the concepts, the connections between magnitudes in an explanatory way and examples on numerical calculations were carried out.

Group-Q (N = 23)**:** Students in this group have only used the tool *quimicalcul*, without the presence of the teacher.

In both groups, the intervention was implemented during a one hour session. The students in each group carried out the proposed exercises of the questionnaire at two time points:

1) After coming into contact for the first time with some basic concepts, but without initiating work with numerical calculations (*Pre-Test*);

2) After the one-hour intervention (*Post-Test*): teacher instruction (*group-T*); familiarization and interaction with *quimicalcul* (*group-Q*).

RESULTS

Each item was marked from 0 to 1, assessing not only the numerical results but also the justifications or lines of argument of the answers. Therefore the global marks of the test range between 0 and 3 points. In *Table 1*, the corresponding data (mean of the total score) are shown as well as the results of the statistical comparison tests used.

According to the results of the Mann-Whitney tests there were no significant differences between *T* and *Q groups* in the total pre-test score ($p > 0.05$). We can therefore conclude, that both groups began at the same level (in any case the means are slightly higher in *group-T*). Across the two groups, a clear improvement in the results of the post-test compared with the pre-test can be observed ($p < 0.05$ in the Wilcoxon signed-rank test).

The comparison between the traditional group and the *quimicalcul* one, after the intervention, also indicates that there were no significant differences between groups' post-test scores, according to the Mann-Whitney test ($p > 0.05$). It is also significant how *group-Q* obtains similar results to those of *group-T* in the post-test, even starting from slightly inferior results in the pre-test.

Table 1: Results of the statistical tests of contrast used.

	Pre-test	***Post-test***	**Wilcoxon signed-rank test**
group-T	Mean = 1.40	Mean = 2.53	Z = -4.21 / p=0.000
group-Q	Mean = 0.97	Mean = 2.56	Z = -3.78 / p=0.000
Mann-Whitney test	U=273.000 / p=0.114	U=276.000 / p=0.243	
Note. As the variables do not fulfil the requirement of normality in their distribution, they are used as statistics of contrast: the Wilcoxon signed-rank test as a substitute of the Related samples T-test and the Mann-Whitney test as a substitute for the Independent samples T-test.			

CONCLUSION AND IMPLICATIONS

We have evaluated the potential of the tool for use in a virtual learning environment like *moodle*, as a substitute for a traditional classroom methodology in solving problems on basic chemical magnitudes in teacher training during the initial phase of the work.

This study shows that *quimicalcul* permits students to get the same results as those achieved with a traditional teaching methodology. This result may be framed within the so called *No Significant Difference Phenomenon* (Russell, 2001), which refers to a type of scientific literature that documents the non existence of significant differences in the results of students who follow alternative education methods. In our case, this “no difference” indicates that *quimicalcul* constitutes a good tool in non face-to-face or distance learning contexts, in the conditions analysed. This aligns with what was found in other investigations which analyse the use of web-based environments as a substitute for traditional teaching methods in science classes at the university level (Lovatt et al., 2007).

As an addition to this work, we are exploring the possibilities of using *quimicalcul* for collaborative learning. As it is embedded in a virtual learning environment it could benefit from the capacities that this offers for interaction among students (forums, wikis).

On a final note, we would like to recommend that teachers to familiarize themselves with this type of tool from their basic training, weighing its advantages and limitations, and thus, appreciating the contexts in which they may be used most favourably.

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A MOBILE COMPUTING SYSTEM DEVELOPED BY DIGITISING THE FORTUNE LINE METHOD

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Abstract: In order to support science learning oriented to conceptual change, we developed a mobile computing system developed by digitising the fortune line method. The theoretical framework for our system is the conceptual ecology model. The system supports the visualisation and sharing of the commitment of numerous learners to multiple ideas.
In addition, we preliminarily introduced the system into Japanese elementary science curricular units and evaluated its possible effect in supporting science learning. Elementary students change their naive concept to a scientific concept after learning in the science curricular unit implemented in the system. The students positively evaluated the system's learning support functions. These results lead us to the conclusion that the system possibly supports science learning oriented to conceptual change.

Keywords: Mobile computing, Conceptual ecology model, Fortune line method

THEORETICAL FRAMEWORK

Conceptual Ecology Model

In science education research, learning science is predominantly viewed as a continual process of conceptual change (e.g., Duschl & Hamilton, 1998). Many science teaching methods and curricula that follow the conceptual change approach place importance on visualisation and the sharing of concepts that individuals carry with them (e.g., Driver, Guesne, & Tiberghien, 1985; Osborne & Freyberg, 1985; West & Pines, 1985).

Various proposals have been made about how to express or describe conceptual change (Chi, Slotta, & de Leeuw, 1994; diSessa, 1993; Vosniadou, 1994). Among these, one of the most widely accepted models by researchers and teachers who aim to promote conceptual change is the conceptual ecology model (Chang, Chang & Tseng, 2010; Posner, Strike, Hewson, & Gertzog, 1982). According to this model, learners' concepts can be described as their ideas and their commitment to these ideas. Therefore, in order to promote conceptual change based on this model, it is essential to allow the visualising and sharing of each learner's multiple ideas regarding a specific learning content and his or her commitment to these ideas.

Although in past studies, various educational technologies have been proposed to support the visualisation of learners' concepts, including text description, semantic networks and imaging (e.g., Linn, 1998; Cañas, Hill, Carff, Suri, Lott, Eskridge, Gómez, Arroyo, & Carvajal, 2004), no technologies have been proposed to support the visualisation of learners' concepts by expressing them as learners' ideas and commitment to them. To enhance curricula and classroom instruction to promote conceptual change, from the viewpoint of educational technology research, it is necessary to develop technologies that use a model well-accepted by researchers and teachers who aim to promote conceptual change as a theoretical base.

The Fortune Line Method as a Representation of Learners' Commitment to Multiple Ideas

What method is employed for visualising and sharing learners' commitment to multiple ideas? We focus on the fortune line method, which was originally a paper-and-pencil method introduced by White & Gunstone (1992) to the field of science education; it is highly regarded for visualising learners' commitment. For example, Kubota (2003) introduced the method in order to probe students' commitments to their supporting theories into the curricular unit 'heat and current' in junior high school. He analysed when their commitments change and showed the method to be very effective and to have powerful functions. Tonishi & Kubota (2004) developed a series of studies to clarify the meaning and effectiveness of the method as a clinical tool for learning in conceptual change-oriented science lessons based on detailed case analysis and suggested that the fortune line method is effective.

However, it is extremely difficult for the method to support numerous learners in sharing their commitment to multiple ideas (the typical class size is 40 in Japanese schools). We assume that by sharing a fortune line drawn to externalise learners' commitment between students or in the entire classroom, we can activate classroom discourse and promote conceptual change in individual students. Based on this assumption, we have attempted to more strongly promote the sharing of commitment through the digitisation of the fortune line method.

MOBILE COMPUTING SYSTEM

Expression of learners' commitment

The learners can input a line by touching the left 'draw the lines' button and touching the input phase (gray-colored zone) on the main screen (**Figure 1**). The user can input different types of lines by touching the middle 'select the pens' button on the main screen and selecting the appropriate pen on the subscreen .

Reference to other learners' commitment

Figure 1: Expression of learners' commitment

Figure 2: Reference on other learners' commitment

The learners can superimpose several different lines of input by several users on their screens by touching the right 'select the lines' button on the main screen (**Figure 2**) and selecting the group member(s) whose line(s) they wishes to view on the subscreen. Using this function, learners can review the differences between their own and others' commitment to multiple ideas, and can discuss their reasons for changes in their commitment.

EVALUATION OF THE SYSTEM: RESEARCH QUESTIONS

The research questions that guide our evaluation study include the following.

(1) Do elementary students change their naive concept to a scientific concept after learning in

the science curricular unit into which the system was introduced?
(2) How do elementary students evaluate the system's learning support functions?

RESEARCH DESIGN AND METHODOLOGY

Participants

The participants in our research were 114 fourth grade students (nine or ten years old) from three classes. They had not used the system or the fortune line method before the research.

Science Curricular Unit

The curricular unit conducted fourteen periods (one period lasted 45 minutes). The learning content was states of matter, and the goal was to change students' naive concept (not all substances exist in the three states (solid, liquid, and gaseous)) to a scientific concept (all substances exist in the three states) through hand-on experiments and discussion.

Viewpoints of Evaluation

(1) Students' Conceptual Change
To answer research question (1), a pre-test and a post-test were conducted before and after the curricular unit. Each question asked whether the substance existed in solid, liquid, and gaseous forms. In each question, students were given options: 'exist', 'do not exist', and 'I have no idea'. It took them approximately 15 minutes to answer the questions. One point was given to students who answered that all states of a substance—solid, liquid, and gas—'exist'. With 17 substances in total, a perfect score was 17.
(2) Evaluation of Learning Support Functions by Students
To answer research question (2), a questionnaire survey of students was conducted after the curricular unit, wherein nine questions were asked about the effectiveness of expression and reference functions of the system for learning support, in other words, items asking students whether learning activities meant to contribute to conceptual change occurred when they used each function of the system. These items were answered using a four-point Likert scale. The survey took approximately 15 minutes.

DATA ANALYSIS AND RESEARCH FINDINGS

Students' Conceptual Change

Figure 4 shows the results of the pre-test and the post-test. While the average score was between 1.5 and 2.5 for the pre-test (class A, 2.3 (SD = 2.0); class B, 1.6 (SD = 1.9); class C, 2.0 (SD = 1.8)), the average score was between 15.0 and 16.5 for the post-test (class A, 15.2 (SD = 2.6); class B, 15.9 (SD = 3.0); class C, 16.1 (SD = 2.5)). Wilcoxon signed-ranks tests were conducted for each score. It was found that the scores of the post-test were significantly higher than those of the pre-test (Z = 5.386 (class A), 5.424 (class B), 5.412 (class C); $p < .01$).

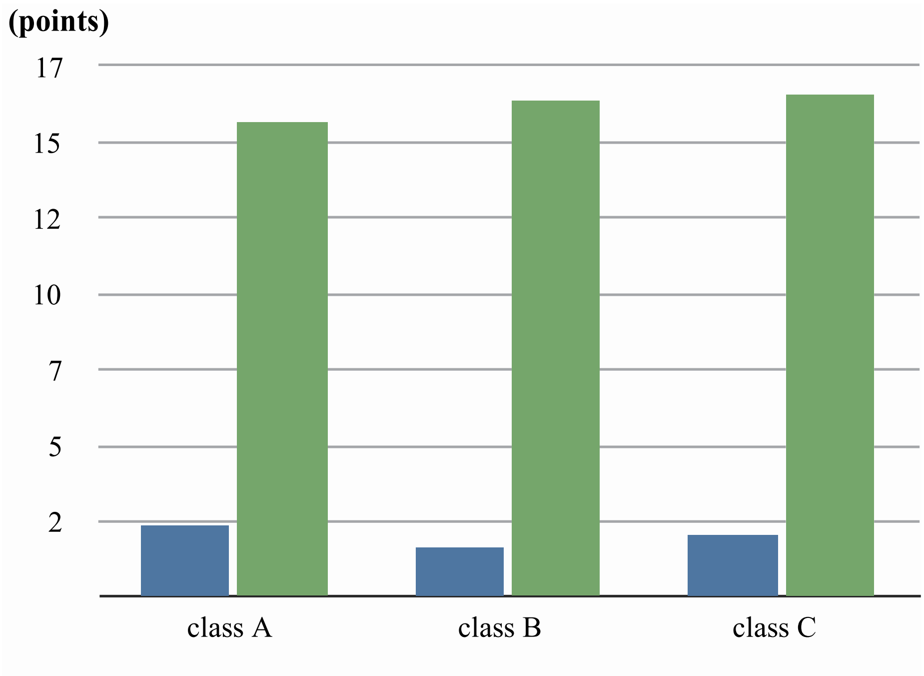

Figure 4: Results of students' conceptual change

Table 1: Results of evaluation of learning support functions by students

	TS	STS	DQTS	DTS
By drawing my line, I understood well which idea I thought was right.	87	22	4	0
By drawing my line, I could explain well which idea I thought was right.	57	43	11	2
By superimposing their lines on my line, I understood well which idea other students thought was right.	98	11	3	1
By superimposing their lines on my line, I understood well the difference between which idea I thought was right and which idea other students thought was right.	93	18	1	1
By superimposing other students' lines on my line, I re-examined my own thoughts about which idea was right.	56	40	11	6
By superimposing other students' lines on my line, I want them to ask questions or comment.	48	42	17	6
By superimposing their lines on my line, active discussions between other students and I began.	52	36	16	9

N=113 (one student absent). TS: Think so; STS: Somewhat think so; DQTS: Don't quite think so; DTS: Don't think so.

Evaluation of Learning Support Functions by Students

Table 1 shows selected question items about the expression and reference functions. Regarding the effectiveness of these functions for learning support, the positive evaluations outnumbered the negative for every item ($p < .01$). Many students acknowledged that the use of expression function supported the reflection of their own conceptual ecologies, and the use of the reference function supported the mutual examination of students' conceptual ecologies in the group discussions.

CONCLUSIONS AND IMPLICATIONS

In this research, we developed a mobile computing system by digitising the fortune line method. In addition, we evaluated a possible effect in supporting science learning. Elementary students changed their naive concept to a scientific concept after learning in the science curricular unit implemented in the system. The students positively evaluated the system's learning support functions. These results lead us to the conclusion that the system possibly supports science learning oriented to conceptual change.

The most important results are that the system supports the visualisation and sharing of the commitment of numerous learners to multiple ideas. This is because providing this support is difficult in the paper-and-pencil method, but is realised by using mobile computing technology (Chan et al., 2006). It is expected that our research will contribute to the increasing popularity of mobile computing technology among the public with regard to the research and teaching practice of science education.

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PART 5: NATURE OF SCIENCE, HISTORY, PHILOSOPHY, SOCIOLOGY OF SCIENCE

Co-editors: Laurence Maurines and Andreas Redfors

The implications of nature of science, its history, philosophy, sociology and epistemology, for science education. The significance of models and modelling for science education as reflected in the particular importance attached to the use of metaphors, analogy, visualization, simulations and animations in science.

This part corresponds to strand 5. It contains 24 papers.

TABLE OF CONTENTS OF PART 5

NATURE OF SCIENCE, HISTORY, PHILOSOPHY, SOCIOLOGY OF SCIENCE

INTRODUCTION

These last twenty years, curricula at all three cycles of education have undergone many reforms, both in Europe and elsewhere. The aim is to give all students the opportunity to encompass the scientific and cultural background that allows them to become responsible citizens, capable of understanding and taking action in a world where science and technology occupy a predominant role. Science programs focus on scientific problem solving with methods and skills to be acquired and attitudes such as critical thinking to be internalized. Emphasis is put on knowledge about the nature of science and scientific activity. In particular, students and future citizens are expected to be able to distinguish between what is science and what is not, and develop skills to be able to utilize scientific theories as parts or bases for discussion and explanations of science and technological phenomena met in current and future everyday life. However, these epistemological issues of scientific education, more or less addressed in different countries and curricula, are often implicit in terms of pedagogical goals, content and activities.

The epistemological dimension of science teaching has attracted the attention of many science educators and researchers. Inquiry-based teaching and history and philosophy of science are proposed as strategies to enhance students' views of the nature of science and scientific activity. The field of research presented in this strand explores numerous questions : teaching contents and objectives, students' and teachers' views, e.g. in relation to religious views, the role of Philosophy of Science, teachers' practices such as inquiry-based teaching and role-playing, the significance of models and modelling, strategies to enhance students' and student teachers' and teachers' views of the nature of science, and research-based implementations of innovative pedagogical units which explicitly or implicitly address the NoS question.

We invite you to enjoy the following articles, *The Strand Editors*

THE CONCEPT OF ANALOGUE MODELLING IN GEOLOGY: AN APPROACH TO MOUNTAIN BUILDING

Edite Bolacha[1], Helena Moita de Deus[1] and Paulo Emanuel Fonseca[1,2]
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Abstract: Analogue modelling has been used, in geological research, since the XIX century. Today, both in scientific investigation and in teaching, it is viewed as an indispensable tool in the reconstruction of ongoing geological phenomena, as well as it is fundamental to infer geological processes that happened throughout Earth's History.
Considering that analogue modelling can be used as a teaching strategy, when teaching Geology or any other experimental science, it is relevant to define the concept and to reveal its applications and vantages.
As it reconstructs and explains past phenomena through the establishment of cause-effect relations with today's analogue phenomena, analogue modelling became an important methodology in the construction of geological knowledge. This line of thinking has been used, for long, by geologists and, when transferred to the classroom, it can deepen the understanding of Geology. In order to do so, teachers need to plan and test carefully these activities, which usually include other teaching strategies simultaneously. These activities promote student's involvement in their learning, therefore developing multiple skills.
The genesis of a mountain range has always been a central issue for Mankind, in general, and for Geologists, in particular. Therefore, as Geology Theories about this matter have evolved, so have evolved the modelling techniques and, consequently, the teachers should adjust these methodologies in the classroom.
Here is presented a new didactic analogue model of (segments of) mountain building adapted from updated scientific models. It was applied in a Geology class with 12th grade students. This preliminary study showed that analogue modelling helped them to reconstruct their mental models about a contextualized episode of regional Geology.

Keywords: Analogue Modelling, Teaching of Geology, Experimental work, History and Epistemology of Geology, Mountain building.

INTRODUCTION

Materials and equipments used in analogue modelling have been evolving since the XIX century (Oreskes, 2007; Schellart, 2002; Ranalli, 2001). Today this methodology is commonly used in scientific research to simulate geological processes that occurred in well determined time and space units. This is done using dynamic models, built to scale, which allow to the manipulation of several variables, selected according to the object of the investigation (*e.g.* Malavieille, 2010).

Despite its limitations (Deus *et al*., 2011), analogue modelling can easily be applied to the teaching of Geology (either formally or non-formally), because planning a didactic activity requires a certain measure of simplification of the geological phenomena, leading to less variables to control. Visualizing the evolution of the studied geological processes empowers this teaching strategy, making it easy to transfer the studied phenomena to the reality, past or present (*e.g.* CNRS-GeoManips). In all cases, the teacher should be careful regarding the way knowledge is presented, making sure that the students fully understand the limitations of the model at hand, especially by discussing the complexity of the phenomenon investigated. This more systemic view of geological phenomena is attainable if its analogue modelling includes a solid scientific and epistemological approach.

GENESIS OF ANALOGUE MODELLING

James Hall de Dunglass, the founder of Experimental Geology, first performed analogue modelling in the XVIII century. Observations made in the field by Hall, James Hutton and John Playfair, were the basis for modelling experiments. Likewise, today investigators collect data on the field (figure 1) to create accurate geological modelling (Newcomb, 2009).

Fig.1. In Geology data is collected in the field to support Theories and Models.

James Hall was influenced by Hutton's theory which considered that rocks were formed by the solidification of magma and its compression, at great depths. So, Hall designed a series of experiments to test this theory, despite the fact that many other investigators (including Hutton) opposed, arguing that the experiments didn't respect real time and space units in which those phenomena had occurred. Furthermore, they stated that the cause-effect relations established by those experiments were not analogue to the natural phenomena (Oreskes, 2007; Newcomb, 2009). Throughout time, this argument was used by the skeptics of experimental Geology, particularly concerning the construction of models (to scale) of mountains and crust deformation, developed during the XIX century (Oreskes, 2007; Ranalli, 2001). This scientific controversy should be discussed when teaching these phenomena (formally or non-formally), conveying to students a more human view of the scientific activity.

The genesis of a mountain range was a key subject among geologists of the XIX century; so, Hall searched for a way to model that phenomenon. Eventually, he was able to find a mechanism to do it, and this became a prototype to future modelling activities on the XIX and XX centuries. After carefully observing geological structures in the field (mainly folds), Hall used simple materials (first, tissues, and later, clay) to simulate the dynamics that originate a folded mountain range (Newcomb, 2009). He applied geometrical similarities (similar geometry of the structures), kinematics and dynamics – from a qualitative point of view (Ranalli, 2001). The calculations of the model's dimensions were based on the figurative geometry, kinematics and dynamic that characterize the natural phenomenon modelled (*e.g.* Hubbert, 1937). This became a very important approach to modelling because the respect for scale enhances the analogical power of the model created, narrowing the gap between the modelled phenomenon and the natural one. This way the experiment is more reliable and easier to reproduce, therefore closer to what a scientific experiment should be.

IMPORTANCE OF ANALOGUE MODELLING

Taking into consideration all the above as well as the current situation of analogue modelling it is admissible that this is an important tool in the construction of geological knowledge. Then, analogue modelling should be included in the teaching of experimental sciences (Gilbert, 2004), along with other kinds of models, for it promotes the comprehension of natural processes' dynamics and their variables. So, it constitutes good opportunities to enforce the use of experimental teaching approaches (Deus *et al.*, 2011). Moreover, analogue modelling is a dynamic way to simulate natural phenomena, simplifying them and allowing for a deeper understanding. This might require some degree of abstraction, especially if the studied phenomenon establishes an intricate net of relations with other natural phenomena. Recent investigation shows that this can be a challenge if the curriculum presents scientific phenomena in an isolated fashion, with little or no intradisciplinarity (Raia, 2008).

Simulating geological phenomena, which occur in 4 dimensions (3 dimensions of the space plus the time dimension), to scale, allows to a variety of multidisciplinary applications, involving several subjects, both scientific and artistic (Deus *et al.*, 2011). Visualizing scientific processes in 4 dimensions contributes to a better understanding of deep time, which is a difficult, yet very important, concept when educating towards sustainability, putting mankind in a relative position in the timeline of Earth's History. The visualization of phenomena in space's 3 dimensions can develop visual skills like: *i)* observe a 3D image object of a 2D image; *ii)* mentally rotate an object; *iii)* imagine sections of an object that has been cut (Gilbert, 2004). All these skills are very important, not only to study Geology, but also when studying engineering or arts. In short, we can say that analogue modelling plays an important role in Science Teaching because it merges several methodologies used in Science, some of which appear in figure 2.

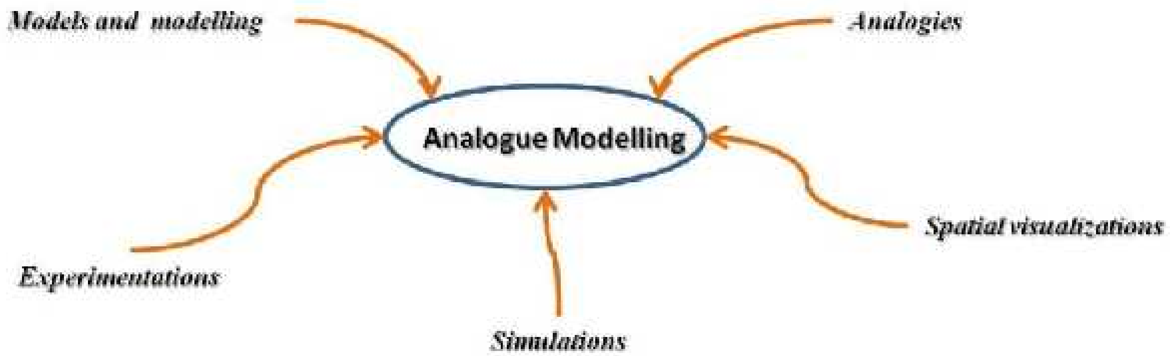

Fig. 2. Examples of methodologies used in Science which are also used in analogue modelling.

Epistemologically, analogue models are a simplified version of updated scientific models, so that they aren't reduced to historical representations of outdated theories or explanations (Gilbert, 2004). When using analogue modelling to present an episode of Geology's History, it should be clearly stated, because it can play an important role in teaching the evolution of geological thinking, as well as to teach current scientific concepts.

MOUNTAIN BUILDING: AN HISTORICAL AS WELL AS AN ACTUAL EXAMPLE

Before Plate Tectonics (1960-1970), many theories came forth to explain the genesis of mountains: from the contractionists (XIX century) to the Theory of the Geosyncline (XX century) (Mattauer, 1980, Oldroyd, 1996; Allegre, 1999). In all these cases, horizontal forces are responsible for the formation of the mountains. What vary, in different theories, are the different sources of those forces (Oreskes, 2007; Oldroyd, 1996).

Hubbert's model (fig. 3) is an example of how historical models can be adapted to current theory. King Hubbert used his sandbox, in 1951, to show some geologic structures and its physical relationships, as well as their causes. Supported by the Theory of Plate Tectonics the same experiment could explain, for example, the relation between the constancy of the Earth's perimeter and the compressive and extensive geological processes.

Fig.3. An episode of Non Formal Education in a Science Centre (Centro Ciencia Viva of Estremoz, University of Evora) with a replica of Hubbert's experiment.

Nowadays, the permanent search for new materials and equipments has led geologists and Geology teachers to the construction of better models. These have been improved by the use of materials with properties that are more analogue to the ones present in natural processes. Therefore, today's teaching models are closer to modern scientific theories.

According to Plate Tectonics, a mountain range develops mainly in a zone where plates converge. To simulate an oceanic plate and a continental border converging (leading to the genesis of a mountain range like Andes), many appropriate analogue models were built and explored, since the 80s of the XX century, by several groups of scientists (Davis *et al*., 1983; Malavieille, 2010; Graveleau & Dominguez, 2008). These are very different from the traditional sandboxes, similar to those used by the pioneers of analogue modelling (*e.g.* Hall, Cadell, Favre referred by Oreskes, 2007), and many times misused in schools to simulate terminal stages of the collision between the plates that originated the Himalayan Range. Taking this into consideration, it is important to study several mountain ranges, to ensure the multiple possible scenarios, therefore developing complex learning skills and avoiding persistent misconceptions.

An alternative modelling activity, is presented here (fig. 4), simulating the genesis of a mountain range, based on several models developed by other investigators (*e.g.* Davis *et al*., 1983; Malavieille, 2010). The model, built at a 1cm:1km scale, and it simulates the genesis of a segment of a mountain range – a accretionary prism, composed by marine sediments, represented by layers of sands with identical internal friction angle and cohesion, therefore analogue to nature. These layers undergo deformation against a backstop, which is analogue to the marine platform or to an already formed section of the mountain, generated by the force inherent to the subducted plate. This force is simulated by a plastic sheet, underlying multiple layers of sand, which moves towards the backstop. Analogue modelling allows varying several parameters, including the height of the layers of sand, the slope of the backstop or the consequences of erosion (Bolacha *et al*., 2011). All together, these convey the idea of a dynamic planet, shaped by multiple variables throughout the Eons of geological time.

Fig. 4. Top picture – early stage of analogue modelling segment of a mountain building. Picture below- the final stage of the same model.

This analogue model was used in a Geology class (12^{th} grade portuguese students) to extrapolate and reconstruct an episode of the geological history of Iberia: the genesis of the accretionary prism of South Portuguese Zone (Ribeiro *et al*., 1979; 2007). Geological maps, texts and images of regional outcrops were used before the analogue modelling activity, in order to help students to construct their mental models (Greca and Moreira, 2000 and references insight) about phenomenon under investigation.

The preliminary results showed that analogue modelling helped the students to reconstruct their mental models about this segment of mountain building along a convergent margin. Before the activity of analogue modelling, most of them had mental models which didn't include the existence of a subduction zone, i.e., closer to the model of the traditional sandbox. Their first mental models about mountain building were consistent with other identified and described by others researchers (*e.g.* Sibley, 2005; Arthurs, 2011). Having the power to induce the reconstruction of the first mental models, analogue modelling is proved to be an important didactic tool. It leads to conceptual change about dynamic processes studied and to the deconstruction of wrong ideas many times included in images and texts in various forms (*e.g.* books, newspapers, and cyberspace).

A more detailed study of this approach in Geology Teaching will be a part of a PhD thesis.

CONCLUSION

Analogue modelling has an important place in Science Teaching because it merges several methodologies characteristic to Science. The use of analogue modelling should be carefully planned taking into consideration the targeted public, so that they can be guided towards the questioning about analogue modelling limitations, namely time, space and the nature of the analogue materials and their rheological behaviour. Furthermore, this teaching strategy should be presented within a theoretical framework, currently accepted by the scientific community, so that it may impart updated knowledge and/or knowledge under construction.

When properly used, analogue modelling can promote conceptual change, leading to a better understanding of present and past geological phenomena.

In future, deeper studies will be conducted in order to confirm the results here presented, that showed that the use of this particular model helped to changed students' mental models about the relevancy of subduction as an important mechanism underlying mountain building. Therefore, their mental models became closer to actual scientific models about mountain building associated with plate convergence.

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EVALUATING STUDENT GAINS IN THE PROFILES PROJECT*

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Abstract: Intervention projects – such as and especially as large as PROFILES – need to clarify the success of their efforts regarding the projects aims. In the case of PROFILES our intervention and efforts are trying to promote - among other objectives the enhancement of students Scientific Literacy.
More specifically, PROFILES aims to promote student gains and thus, the PROFILES project tries to

- balance the attitudes of students toward science and the science education they receive,
- negotiate the meaning and relevance of science education so that science lessons will become more meaningful in eyes of the participating students,
- enhance students intrinsic motivation to learn science and
- foster their abilities and skills especially in the field of learning approaches to science inquiry making justified decisions regarding socio-science and science related issues.

This publication will introduce a theoretically and empirically sound model of teaching and learning science as well as questionnaires and instruments for the investigation of the aims mentioned above. Furthermore we will present and discuss results from different intervention studies obtained by means of the different questionnaires and instruments (mentioned above). The results will be used as examples to offer insights into the potential of the questionnaires and pre-post-intervention-and-control-group design approach. In addition first results from the PROFILES Working Group of the Freie Universitaet Berlin will be presented.

Keywords: IBSE, student gains, Motivational Learning Environment (MoLE) Model, scientific competencies and life skills, project evaluation and questionnaires.

1 INTRODUCTION: PURPOSE OF PROFILES

PROFILES is the acronym for: Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science. As mentioned in the PROFILES Project symosium at ESERA 2011 (Bolte et al., accepted; see this proceedings), PROFILES is aiming to implement existing IBSE-focused science teaching materials by means of (long-term) teacher training courses to support teachers' continuous professional development (CPD). The PROFILES consortium members are convinced that the PROFILES CPD programme will convince teachers to take ownership regarding the implementation of evidence based best practice learning environments in order to foster science education and scientific literacy among their students (PROFILES 2010).

Intervention projects such as – and especially such as large as – PROFILES need to clarify the success of their efforts regarding the projects aims. In the case of PROFILES our intervention and efforts are trying to promote - among other objectives (e.g. the increase of teacher ownership) - the enhancement of students' scientific literacy (Gräber & Bolte 1997).

To be more specific, PROFILES aims to promote student gains and by trying to…

(a) balance the attitudes of students toward science and the science education they receive,
(b) negotiate the meaning and relevance of science education so that science lessons will become more meaningful in eyes of the participating students,
(c) enhance students intrinsic motivation to learn science and
(d) foster students abilities, skills and competencies especially in the field of learning approaches to science inquiry making justified decisions regarding everyday life, socio-scientific-science and science related issues.

2 FRAMEWORK AND CONCEPTION OF THE PROFILES PROJECT EVALUATION CONCERNING STUDENT GAINS

"Europe needs more scientists" is the title of the high level group report chaired by M. Rocard and published by the European Commission (2004). But, young adults won't apply for a job in the sciences,

- if their experiences in science are not meaningful,
- if science instruction is less motivating,
- if scientific concepts are considered as irrelevant and
- if persons working in the sciences associate with a negative stereotype (Bertels & Bolte, 2009; 2010; see figure 1).

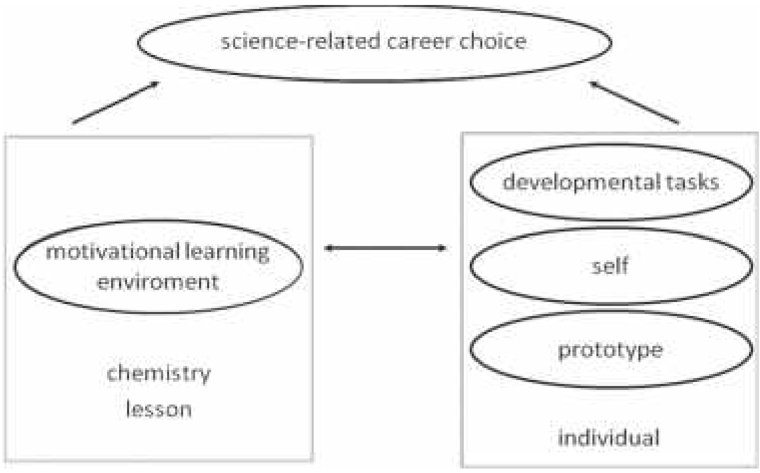

Figure 1: Model of selected variables which effect students' choice of a career in the sciences (according to Bertels & Bolte 2010)

With these aspects in mind, the PROFILES project places a special emphasis on identifying student gains in the affective component – esp. in the (intrinsic) motivational part of science learning and scientific literacy. Above and beyond - but not exclusive - PROFILES also pay attention to specific scientific competencies (e.g. scientific inquiry skills and/or skills of justified and/or informed decision making).

Analysing the outcomes of the PROFILES intervention, linked to the teachers continuous professional development and the promotion of the PROFILES teachers to take ownership for more innovative practices in their science classes, the question of the impact of the project on students is the core part of the PROFILES Work package 7 (see Bolte et al. in this proceedings and/or PROFILES 2010). But evaluating the effectiveness of the PROFILES interventions from a student perspective does not mean that cognitive components are analysed only by means of conventional knowledge tests or that the focus of the evaluation should be on those objectives as they are often described in national education standards. Attention is also paid to evaluate students' motivational gains and the development of their affective skills as well as the students' attitudes related to science, science education and other fields of the sciences (such as (not) choosing a vocational career in a field of the sciences; European Commission, 2004).

Therefore, the PROFILES consortium hypothesises that if science teaching is experienced to be meaningful and profitable, in the students' opinions, (see variable "relevance" in fig. 2), science education and learning science will be strengthened with regards to cognition and contents (see variable "outcomes" in fig. 2) as well as concerning the affective domain of learning science (see variable "satisfaction" in fig. 2). A mixture of cognitive and affective variables which PROFILES will take into consideration are variables such as interest and attitudes towards science, science learning, the image of science and/or of people working in the sciences (also attributed to the variable "outcomes" in the model of fig. 2).

However, the PROFILES consortium agree to the opinion of the European Commission that effective teaching is recognised as a great contribution to a "*generally increased knowledge in the sciences for the young generation*" (FP7-SiS-call, 2009, p. 22). Therefore, science education – as it is promoted by the PROFILES project – can be taken to be successful if the evaluation demonstrates that the *"falling interest in key science topics can be removed and if the lessons foster stimulating intrinsic motivation"* (FP7-SiS-call, 2009, p. 20). High intrinsic motivation in learning science (Streller, 2009; Bolte, 2006), enlightened attitudes towards the sciences (Streller, 2009) and a reflective self-to-prototype-matching concerning the prototype regarding employees in the sciences and one's own self-image (Bolte & Bertels, 2010) are seen as reliable predictors to assess whether an "*increase in the numbers of young people in Europe taking up scientific careers*" (FP7-SiS-call, 2009, p. 22) is likely (Bertels & Bolte, 2009; 2010).

The theoretical framework of the PROFILES student gains evaluation is based on a model of science instruction and the effects of important variables of innovative and motivational learning environments on students' outcome (Bolte, 2006; see figure 2). The core part of this model is related to motivation and interest theories as well as to recommendations from learning environment research (Fraser, 1989; Hoffmann et al., 1998; Gräber, 1998; Deci & Ryan, 2002; Bolte, 2006; Streller, 2009).

The so called MoLE-model (MoLE is the acronym for: Motivational Learning Environment) has been tested by means of LISREL Multi Level Structure Analyses (Koeller & Bolte, 1994). These analyses show that the model is theoretically sound and empirically valid. Furthermore, other analyses reveal that the variables of the MoLE-model and the scales of the questionnaire instrument which is based on this model are highly reliable and also valid regarding the construct validity of our theoretical assumption (Bolte, 2006).

In 2009 Bolte extended his MoLE-model to clarify the questions such as:

(a) 'What is "relevant" from a students' perspective in science lessons?' and
(b) 'How can the variable "outcome" be explained in more detail?'

To analyse the question concerning the variable "relevance" Bertels and Bolte (2009) take the "Theory of Developmental Task" developed by Havighurst (1972) as a basis. This theory was adapted and further and elaborated by Meyer (2006) and Schenk (2005) within their theory of the “learners’ experiences in education and educational development”. Hence, in order to offer more information about the (potential) outcomes, we differentiated this outcome-variable regarding the evaluation of

- “balanced attitudes” (such as the “self-to-prototype-matching” (Hannover & Kessels, 2004) and the science related self-concept of abilities (Hannover, 1998; Bertels & Bolte, 2009; 2010)), as well as the analyses of
- “students competencies” (such as “students’ inquiry qualification” (Erb & Bolte, 2011) and students competencies in making informed and reflective socio-scientific and science related decisions (Bolte, Kirschenmann & Streller, 2009)).

All the mentioned scale have been tested in past studies, and the findings from these empirically based analyses certify all scales (variables) a high level of objectivity and high values of reliability (Cronbach’s alpha; see Bertels & Bolte, 2010; Erb & Bolte, 2011; Bolte, Kirschenmann & Streller, 2009).

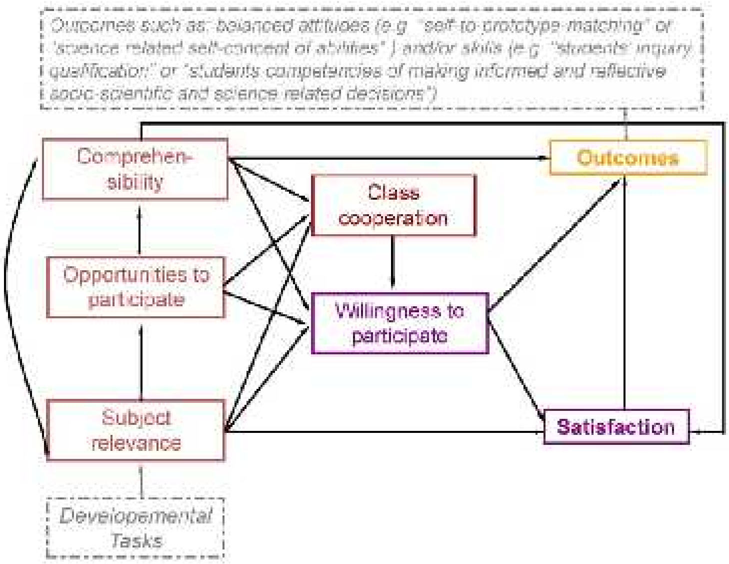

Figure 2: Extended Version of the Motivational Learning Environment Model (according to Bolte 2006)

METHODS

The questionnaires and instruments developed and tested by the leader of the PROFILES Work package 7 and his staff members have been adapted for the PROFILES project to analyze and evaluate the effects of the PROFILES intervention; for example:

- the Motivational Learning Environment Instrument (MoLE; Streller 2009; Bolte 2006);
- the Self-to-Prototype-matching questionnaire (StoP; Bertels & Bolte, 2010);
- a questionnaire assessing the support offered to students dealing with selected developmental tasks of young adults (e.g. occupational orientations, self-orientation, individual reflective value system; Bertels & Bolte, 2010),
- the Inquiry Qualification Questionnaire for the analyses of scientific inquiry skills (IQ^2; Erb & Bolte, 2011), and/or

- the Questionnaire to analyze competencies in the area of making informed and reflective socio-scientific and science related decisions (Bolte, Kirschenmann & Streller, 2009).

The PROFILES project evaluation is designed as pre-post-intervention-and-control-group study. Before the start of the long-term professional development intervention data will be collected from the participating teachers' classes (pre-test; intervention-group) and from classes of teachers who don't participate in the PROFILES teachers continuous professional development programme (control-group). At the end of a school term, both groups will be re-tested with the same instruments again (post-test; in the intervention and the control-group classes).

RESULTS

Results from different intervention studies obtained by means of the different questionnaires and instruments mentioned above are used as examples to offer insights into the potential of the questionnaires and pre-post-intervention-and-control-group design approach. The results and findings from our research can be summarized as follow:

The analyses of our MoLE investigations and especially the comparison of the so called "Wish-to Reality-Differences" points to some (important) reasons why many students end their physics and chemistry classes at the earliest possible grade and why they might not choose a vocational career in the sciences; for example:

- teachers of chemistry and physics often teach *topics which are not relevant to students with respect to their everyday life and/ or to socio-scientific issues*,
- *female students* assess the learning environment in chemistry classes less favorably than male students do,
- *teachers* have problems in anticipating their students' learning environment assessment and need help for the evaluation of the learning climate in their classes,
- *teachers* are not easily inclined to change the subjects of their instruction to topics of increased relevance although their own estimation would support this.

Comparing the self-images and prototypes of German students and of trainees in the vocational field of the sciences we find differences between the self- and the prototype assessments in both groups, but the difference between self-image and prototype of the trainees is much smaller than the differences analyzed in the group of students. All in all, the prototype - the students have - is rather negative, and their self-image and prototype do not match at all. In other words, the negative prototypes students have might actually be one important factor that influences their choice of career.

CONCLUSIONS AND IMPLICATIONS

The use of the instruments we tested and the design of the PROFILES project evaluation we tried out in the past make analyses possible which clarifies the effect(s) of intervention programs, such as the PROFILES project, on student gains. Furthermore, past studies by means of the introduced questionnaires and the chosen evaluation design show that "*various pre-conditions and cultural differences*" (FP7-SiS-call, 2009, p. 20) of students can be taken into consideration. Beside this, by means of the here recommended evaluation approach a "*differentiating [between] girls' and boys' interest*" (FP7-SiS-call, 2009, p. 21) and the specific variables of students' learning outcome becomes possible, reliable and valid.

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PROFILES* – PROFESSIONAL REFLECTION-ORIENTED FOCUS ON INQUIRY-BASED LEARNING AND EDUCATION THROUGH SCIENCE

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Abstract: PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) promotes Inquiry-Based Science Education (IBSE) by supporting science teachers to develop more effective ways to teach students, aided by science education actors (stakeholders). The project is based on “teacher partnerships” aiming to implement existing, exemplary, context-led, IBSE-focused, science teaching materials. Long-term teacher training courses, based on challenges of implementing student relevance is set to improve skills in developing creative, scientific problem-solving and socio-scientific related learning environments. A crucial aim is the strong dissemination of evaluated approaches, reactions from different actors (stakeholders) and insights of the PROFILES Project, making use of the Internet, the PROFILES Newsletter and other media.

Keywords: IBSE, continuous professional development (CPD), stakeholder networking, best practice, scientific competencies, life skills, 21st century science, evaluation.

INTRODUCTION: PROFILES BACKGROUND AND PURPOSE

A student motivational, socio-scientific approach to science teaching is promoted by PROFILES currently one of several European FP7 funded projects in the field of “Science in Society” (PROFILES Consortium, 2010; Bolte, et al. 2012; Bolte & the PROFILES Consortium Members, in progress). The PROFILES Consortium, consists of 21 partners from 19 different countries (status quo: May 2011), is promoting IBSE through raising the self-efficacy of science teachers to take ownership of more student-relevant ways of teaching, supported by stakeholders views. The project is grounded on ‘teacher partnerships’ implementing existing, exemplary, context-led, IBSE-focussed, science teaching materials, guided by long-term teacher training, reflecting on challenges identified by participating teachers to raising their skills in developing creative, scientific problem-solving and socio-scientific related learning environments; learning environments which embrace students’ intrinsic motivation to learn science and enhance competencies in undertaking scientific inquiry and socio-scientific decision-making. Measures of success are through determining

(a) the self-efficacy of science teachers in the PROFILES approach and

(b) the attitudinal gains by students towards science and their science education.

The dissemination of PROFILES approaches, reactions from a range of stakeholders and insights from associated research and evaluation form a further key project target. The intended outcome of PROFILES is science education become more meaningful to students, more strongly related to 21st century science, more associated with generic education and especially promoting and enhancing IBSE in school science. In short, the ultimate PROFILES target is to raise teacher's continuous professional development (CPD) and students' scientific literacy.

FRAMEWORK AND CONCEPTION OF THE PROFILES PROJECT

The PROFILES project aims at ensuring the improvement of science education by offering innovative scientific learning opportunities for pre- and in-service teachers, teacher educators, as well as students within school and in non-formal education centres. The PROFILES consortium members are confident to reach this aim by:

- **Establishing close cooperation and networking of the consortium with stakeholders** (see table on WP2 'Support and Co-operation' and WP3 'Stakeholder Views') which provides strong teacher guidance to assist in removing possible obstacles and to build up confidence that the disseminated materials, conceptions and programmes are being enacted, bearing in mind stakeholder views and evaluated, in terms of approval, by stakeholders.
- **Providing teacher training and innovative inquiry-based teaching approaches** to introduce methods of, and teaching modules for, learning and teaching IBSE inspired science, which feature specifically relevance-identified modules (see WP4 'Learning Environments'), and training programmes linked to classroom intervention support. The introduction of PROFILES ideas into pre-service student teacher programmes, by enhancing science educator awareness and interest, is also intended (see WP5 'Teacher Training').
- **Developing strong(er) teacher professionalization and enhancing teacher self-efficacy** through building on an intervention, guiding teacher reflective processes and teacher initiating use-inspired research accomplishments. Additionally professionalization is enhanced through teacher ownership (see WP6 'Teacher Ownership') enacted through adaptation of state-of-the-art teaching modules related to cultural pre-conditions and gender factors, as well as reflective portfolios and action research projects.
- **Evaluating the outcomes of the intervention linked training regarding student gains** (see WP7) **and the promotion of teachers take ownership of more innovative practices**, concerning the students in terms of both attitudes towards the teaching approaches, and their perception of, and interest in science-related learning and careers in the sciences.
- **Disseminating the PROFILES ideas, materials and outcomes** and its potential for greater adoption through establishing teacher networks and interacting with other regional and national networks, as well as networking with other innovative IBSE science teaching projects (see WP8).

The PROFILES educational philosophy is introduced to central stakeholders within the education system of each consortium country via eight inter-dependent work packages (rf. Table 1 and Figure 1). An intended outcome, through continuous professional development (CPD) of science teachers, is to create interactive local, regional, national and Europe-wide teacher networks which positively influence teachers' competence and confidence to promote IBSE-related science teaching and hence raise their self-efficacy to teach in an innovative – more student centered, context-led IBSE – manner, as well as in valuing use-inspired research ideas. This will be evaluated by means of systematic, statistically-based methods, as well as with the help of action research activities.

Work Package	Short title	Coverage
WP 1	Management and evaluation	Project management and external evaluation.
WP 2	Partner co-operation and professional support	Partner professional support to guide PROFILES as per the intended philosophy, goals, outcomes and stakeholder views.
WP 3	Stakeholder involvement and interaction	Bridging the gap between science education researchers, educators, and local actors (stakeholder network and co-operation).
WP 4	Learning Environment	Preparing focus of teacher training materials and identification of IBSE related teaching modules plus their modification and enhancement, based on evaluative feedback and involvement of additional teachers in PROFILES.
WP 5	Teacher Training and Intervention	Planning and Implementation of the (longitudinal) teacher training programme and inter-related teacher interventions.
WP 6	Teacher Ownership	Building on WP5 and reflecting and evaluating the effectiveness and impact of the (longitudinal) teacher training programme with special emphasis on teacher ownership and reflective practices.
WP 7	Student Gains	Evaluating the effectiveness and impact of the teacher training programme/intervention and development of teacher ownership by focusing on student outcomes.
WP 8	Dissemination and Networking	Dissemination at a national, international and worldwide level and establishment of a PROFILES teacher network interrelated to other teacher networks operating at a local, regional, national or Europe-wide scale.

Table 1. Work packages of the PROFILES Project.

Within this intended outcome, and by means of a (long term) teacher continuous professional development (linked and supported by stakeholders) a further key target of PROFILES is to convince teachers that the methods they have studied within the PROFILES programme and tried out during the PROFILES classroom interventions in their science classes will, and can, strongly improve the quality of their own science teaching.

Furthermore, teachers - especially those who participate in the PROFILES longitudinal CPD programme – will become convinced of the need for change in conventional practice. The new viewpoints they have learned in the PROFILES teacher meetings they will discuss with their colleagues; especially the need to interact and to seek for further support by networking with other colleagues (e.g. colleagues of other subjects in their schools, or from 'nearby schools' etc.). Beside this, the PROFILES Consortium expects that the teachers, participating in the PROFILES programme, will be motivated to disseminate their new experiences and the PROFILES IBSE teaching and learning materials through informal and/or formal teacher forums. This will be encouraged both through activities organized by the Consortium partners (e.g. via the PROFILES websites and dissemination network) and by follow-up training courses and informal teacher meetings after the longitudinal teacher CPD programmes at a regional, national and Europe-wide level.

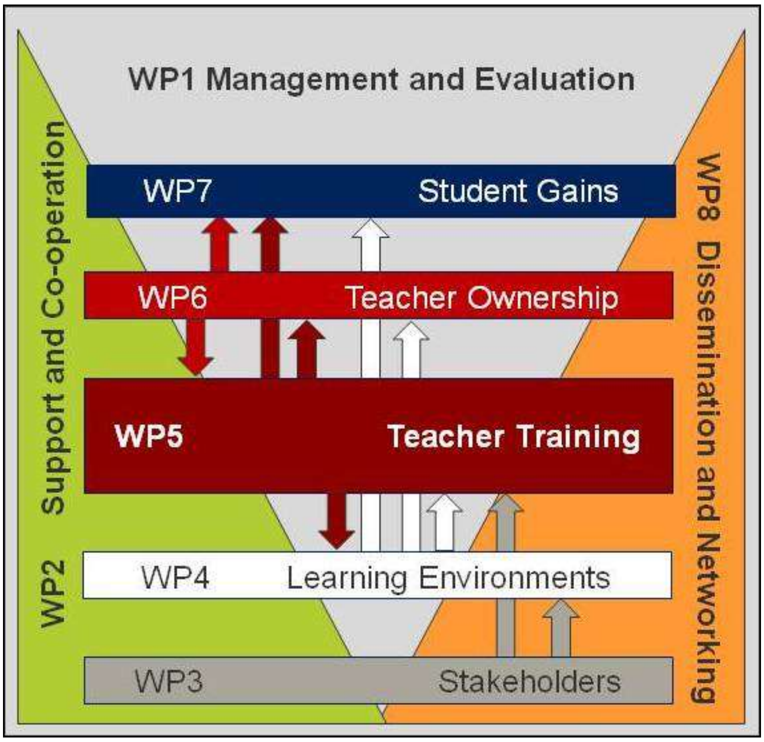

Figure 1. Interdependencies of the PROFILES Project's Work packages

A reflective impact component, first guided by the consortium partners, but later by specific teachers (referred to as 'lead teachers'), is designed to follow-on from the initial training and intervention to raise teachers estimation of responsibility for self-evaluating approaches to analyse students' enhancement of scientific literacy in the participants' schools and/or classes of teachers' special interest groups. These aspects, linked to teachers' self-efficacy, will motivate PROFILES teachers to evaluate their own professional developments as well as guide other colleagues in investigating the success of their teaching; for example by means of action research methods. Professional attitudes like these, we term "teacher ownership".

Confidence that the objectives of the PROFILES Project - the effective and sustainable improvement of teaching through the promotion of self efficacy and teacher ownership - will be reached, is strengthened through evaluation, by both formal and summative assessment. Our evaluation will focus on students' cognitive and affective learning and also on the teaching methods, approaches and materials used within the PROFILES intervention lessons. By means of the PROFILES evaluation it is intended to indicate where improvement is justified and where additional efforts are necessary to improve IBSE to meet stakeholder wishes, as well as teachers and students needs.

From the initiation of the project in December 2010, the PROFILES Consortium emphasises the dissemination of products, experiences and evidence-based outcomes of the project; starting with specific national PROFILES websites in each consortium partner's language and by encompassing the international PROFILES platform (www.profiles-project.eu). But realising that dissemination by partners alone is insufficient, further efforts are included by the PROFILES Consortium to support teachers and stakeholders in general, to appreciate the project and its developments (e.g. by means of strengthened teacher networks and their networking). Through these efforts and interacting with other teacher networks, links are widened, ideas of IBSE are disseminated and teacher-teacher interaction enhanced across borders (insofar as language aspects permit).

Our first steps in dissemination have been taken by presenting the PROFILES Project and its coordinating and supporting actions at international conferences (e.g. Scientix 2011 in Brussels, ESERA 2011 in Lyon, and GDCP 2011 in Oldenburg). A key future event through which it is possible to interact with the PROFILES project and its consortium members, teachers and stakeholders, will take place in Berlin 2012 from the 24th to 26th September, 2012. Those interested to meet PROFILES and the PROFILES actors are invited to participate in this, the 1st International PROFILES Conference on Stakeholders Views and the Enhancement of Inquiry Based Science Education. For more information, please, visit the PROFILES website: www.profiles-project.eu.

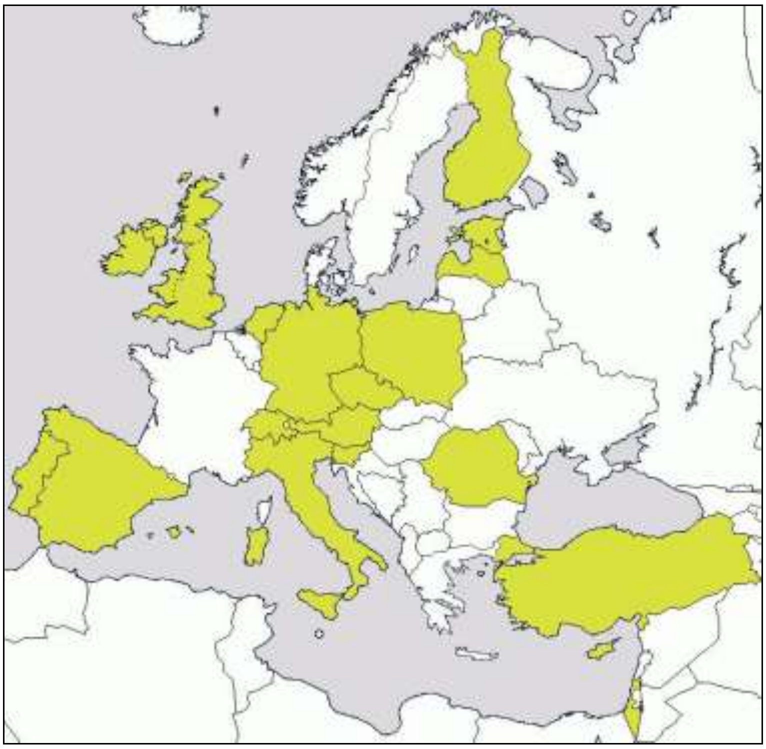

Figure 2. Overview of the countries involved in the PROFILES Project's Consortium*

* The PROFILES Consortium consists of: Freie Universität Berlin (Coordinator, Germany); University of Tartu (Estonia); Weizmann Institute of Science (Israel); Universität Klagenfurt (Austria); Cyprus University of Technology (Cyprus); Masaryk University Brno (Czech Republic); University of Eastern Finland (Finland); University College Cork (Ireland); Universita Politecnica delle Marche (Italy); University of Latvia (Latvia); Utrecht University (Netherlands); University of Maria Curie-Sklodowska (Poland); University of Porto (Portugal); Valahia University Targoviste (Romania); University of Ljubljana (Slovenia); University of Vallalodid (Spain); University of Applied Sciences Northwestern Switzerland (Switzerland); Dokuz Eylul University (Turkey); University of Dundee (UK); University of Bremen (Germany); International Council of Associations for Science Education (ICASE, UK).

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ASSESMENT OF THE IMPACT OF SCIENCES STUDIES IN UNDERSTANDING THE NATURE OF SCIENCE IN SIX COUNTRIES

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Abstract
This study shows the results of the Questionnaire of Opinions on Science, Technology and Society (Spanish acronym, COCTS) applied to students starting and finishing their undergraduate degrees in university careers related to basic science or teaching training in natural sciences in Colombia, Mexico, Argentina, Spain, Portugal and Brazil (Spanish acronym PIEARCTS). The topics evaluated were epistemology, history and internal and external sociology of science (Nature of Science and Technology, NoS&T). Using variational analysis it was stated that the background in science was not a meaningful influence in change of attitude on the NoS&T. Students from Spain and Argentina who had completed studies in science (senior students) had better-informed attitudes than those who just began college (freshman). On the other hand, students from Portugal, Colombia, Mexico and Brazil did not show big differences in attitude.

Keywords**:** Nature of Science. Science, Technology and Society. Science Education. Conceptions assessment.

The Science, Technology and Society (STS) educational movement advocates for a scientific education with a more humanistic approach, including the social dimension of science and technology in science education, taking into consideration ethical values towards science and technology and a democratic point of view to take informed decisions in public matters.

The inclusion of epistemology, history and sociology of science as part of the meta-theoretical discourse has placed science in another context and under another value. According to internal and external factors, science is considered part of a broader cultural context where scientists are product of the same culture. Stated briefly, it is accepted that there is a social contract among society, science and technology, more or less implied, where each supports and builds up the other. The new contextualization of science has produced recent educational research about teachers and student's attitudes thus creating ideas about NoS&T more complex but less absolute.

Studies from Manassero and Vázquez (2002) and particularly Liu and Tsai (2008) examine the differences among different groups of science and non-science students attending two public universities. Generally speaking, students did not have sophisticated beliefs about the epistemology of NoS&T, specifically those referred to theory-laden and cultural dependent aspects of science. Students who were acquiring academic background to become science teachers attained the lowest scores among the groups evaluated (science, non-science and science education students). The bottom line is that science education should be relevant to the complexity of these epistemological beliefs.

Within this framework and the goals of the PIEARCTS project, a comparison of the attitudes held by freshman and senior students of science in some aspects of NoS&T is presented in order to identify relevant differences between those two groups. It is assumed that students who complete their studies in science (seniors) show more sophisticated beliefs than students who begin college (freshman).

METHOD AND INSTRUMENT

According to the PIEARCTS methodology, the COCTS questionnaire (Forms 1 and 2) was applied according to 30 items related to NoS&T. For the comparative analysis, the attitudinal indexes from two types of students were taken into account, through the mean and standard deviation for each question. The analysis stated that the closest the index value to the positive side (+1) the higher the attitude's appropriateness and the more informed. While the closest the index value to the negative side (-1) the lower the attitude's appropriateness, uninformed and naive. To determine significant differences, ANOVA was performed based on the interval $p < 0.01$. The differences weight was established according to its relevance.

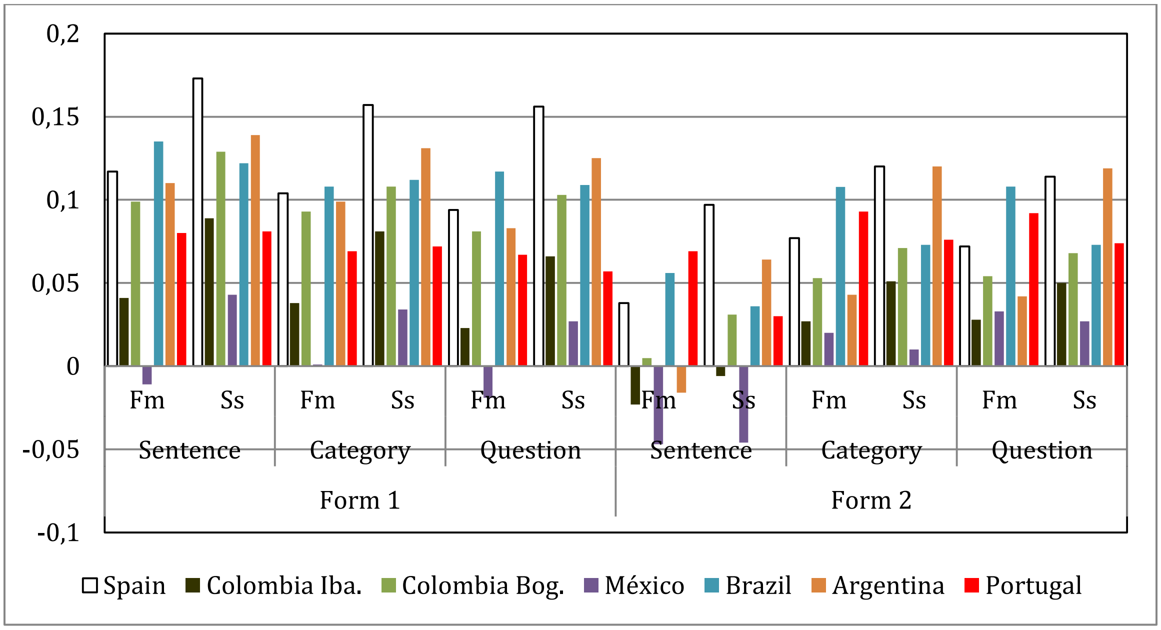
SAMPLE

The total of students answering the COTCS questionnaire in six countries were two thousand three hundred twenty four (2324). One thousand one hundred seventy four (1174) answered Form 1. From this sample, six hundred sixty five (665) were freshman students and five hundred nine (509) where senior students. Form 2 was answered by one thousand one hundred fifty (1150). From this sample, six hundred fourteen (614) were freshman and five hundred thirty six (536) were senior students.

RESULTS

Figure 1 shows the overall averages in sentences, categories and items evaluated in the COCTS (Form 1 and 2) questionnaire by identifying the information level of NoS&T for each group of students (freshman and senior) in the six countries reviewed.

Figure 1. Overall averages for a group of freshman (Fm) and senior students (Ss) of six countries based on sentences, categories and items in Form 1 and 2.



Attitudinal averages do not exceed 0.19. This is statistically interpreted as neutral attitudes towards NoS&T. Students who answered Form 1 in COCTS questionnaire revealed better-informed attitudes than those students who answered Form 2. This means that there are less informed attitudes on issues related to the definition of technology[1], the role of industry, educational institutions[2], social responsibility information, social decisions, gender equity, classification schemes, role of assumptions and epistemological status[3].

[1]For example, students believe that technology is an application of science (Sentence, 10211B). They also think that heavy industry should be moved to underdeveloped countries to save developed countries and future generations of pollution (Sentence, 40161,A).

[2] On the issue related to educational institutions, students do not consider necessary to study science, because not everyone can understand it. They also believe that science is not really necessary for everyone (Sentence, 20511G).

[3] On issues related to the epistemological component of the NoS&T, particularly, the classification schemes and epistemological status of science, students consider that the classifications made by scientists, because they have tested over many years of work (Sentence, 90311A). They also think that scientists discover laws, hypotheses and scientific theories (Sentence, 91011A).

The Spanish and Argentine freshman students have the highest rates in both Form 1 and 2. These students have better-informed attitudes than freshman students, as one would expect. On the other hand, freshman and senior students from Spain, Argentina, Portugal and Brazil show similar values in Form 1.

Based on the issues in Form 2, senior students demonstrate less informed attitudes compared to freshman students. This means that the process of education in science does not imply a better understanding of the NoS&T. According to sentences in Forms 1 and 2 and items in Form 2, Mexican students got the most negatives indexes, indicating misinformed attitudes. Regarding the issues on the questionnaire, Argentinean and Mexican students did not show significant or relevant differences, based on variational analysis. (t> 0.3). This means that science and technology courses do not have an impact on the improvement or acquisition of informed beliefs on NoS&T.

Table No 1 presents the effect size on the issues where the differences between the two groups are significant. Spain has the highest number of significant and relevant differences (9/30). Eight of these are of senior students, among the thirty items assessed.

Table No.1. Significant and relevant differences on items

COUNTRY	FORM 1	EFFECT SIZE	FORM 2	EFFECT SIZE
Spain	F1_40161 Social responsibility contamination.	0,6393	F2_10421 Interdependence quality of life	0,6673
	F1_30111 Interaction STS	0,5206	F2_20511 Educational Institutions	0,6376
	F1_40531 Life welfare	0,3783	F2_60521 Women like men	0,4994
	F1_40221 Moral decisions	0,3621	F2_50111 Union two cultures	0,4251
			F2_40421 Application to daily life	-0,3792
Portugal			F2_90311 Classification schemes	-0,6032
			F2_70211 Scientific decisions	0,3796
			F2_40421 Application to daily life	-0,3138
Colombia (Bogotá)	F1_20141 Government politics of a country	-0.6501	F2_90521 True assumptions	-0.3186
Colombia (Ibagué)	F1_40221 Moral decisions	0.8300	F2_10421 Interdependence quality of life	-0.5036
			F2_20511 Educational Institutions	-0.8782
			F2_40421 Application to daily life	-1.3278
Brazil	F2_70211 Scientific decisions	0,37963	F2_40421 Application to daily life	-0,31389

Only fourteen items out of the thirty evaluated had significant and relevant differences. Freshman students have better information than seniors on topics related to Government politics of a country[4], the relationship of technology in daily life[5], classification schemes, and the nature of the assumptions in science, the interdependence of science and technology and its effect on quality of life.

CONCLUSIONS AND IMPLICATIONS

The analysis of the differences between freshman and seniors students allow us to value the efficiency of college education in science and technology to understanding the NoS&T. The empirical evidence does not enable to establish that such studies improve significantly the understanding of Nos&T. The total number of sentences, categories and items that had relevant positive differences is low when comparing them with the 30 variables analyzed. Some comparisons present significant negative differences, that is to say that the understanding of the NoS&T gets worse over the school years. As a result of a variational analysis, it is stipulated that, based on COCTS, college education in these six countries has no impact on attitudinal change in the relationships to STS. These considerations have to be taken into account as an explicit purpose in college curriculums.

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[4] Freshman students, for example, think scientists are influenced by the politics of their country, because governments set policy for awarding research funds to some scientific research projects and not to others (Sentence, 20141B).

[5] Freshman students say the systematic reasoning learned in science classes allows them to solve problems and understand a wide variety of physical events (Sentence, 40421C).

UNDERGRADUATES' BELIEFS ON THE NATURE OF SCIENCE: A COMPARISON BETWEEN SCIENCE AND HUMANITIES

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Abstract: The purpose of this research was to analyse undergraduate science and humanities students' beliefs on the nature of science and technology (NoST). The study was carried out with 1037 Mexican first graders and senior college students. The instruments used are the Questionnaire of Opinions on Science, Technology and Society two formats (Manassero & Vázquez, 1998). Overall, both groups of students (science and humanities) showed bad informed beliefs of NoST and in several cases, humanities students' showed beliefs more informed than science students, mainly on issues related to science and technology in society, such as social responsibility for pollution, conception of technology, and features of the scientific community. These results show that science students are not receiving enough training in science, as they are not showing a better understanding about NoST. This study could be the basis for design proposals to improve science and technology education.

Keywords: Nature of science, science-technology-society, undergraduate students' beliefs, science and humanities.

BACKGROUND

There are several problems underlying nature of science and technology teaching. One problem stems from the beliefs about S&T, most of students and teachers have uninformed and inappropriate views about science, scientists, scientific method, and scientific work. Furthermore, exists a reductionist view of technology and misunderstanding its relationship with society and environment.

FRAMEWORK

The main goal for science education in the last few decades has been the students developing informed views of nature of science (NOS); a wide research it has been carried out, mainly with basic education students (Abd-El-Khalick & Lederman, 2000; Lederman, 1992). However relatively little attention has been paid to college students' NOS views. Review of the literature has shown different findings about nature of science, some studies have assessed the nature of scientific knowledge views held by college students with different majors, for example Schommer (1993) showed that epistemological views of social science at majors were less sophisticated than those of technological science majors. Other researchers like Jehng, Johnson, and Anderson (1993) found that students in social sciences and humanities were more likely than engineering and business students to view knowledge as uncertain. These findings emphasize the relevance to assess and take into account the beliefs and attitudes about NoST.

RATIONALE

According to some authors (Abd-El-Khalick, 2006; Lederman, 2006; Abd-El-Khalick & Lederman, 2000) exploring the meanings that college science students ascribe to various aspects of NOS is significant because a good understanding of NOS is an essential component of scientific literacy, which is a goal for *all* citizens in participatory democracies (AAAS, 1990; NRC, 1996). In addition, research on teaching and learning about NOS in K-12 and science teacher education indicates that the assumption that students learn about NOS implicitly through engagement in science based activities is not empirically valid (Abd-El-Khalick & Lederman, 2000). That is, NOS should be taught involving to the students in discussions about science activities and their implications for resulting knowledge (Lederman, 2006).

Besides, the college students will join the economic and politically active population of the country.

PURPOSE

Thus, this study was aimed to explore and to compare the beliefs about nature of science and technology and their relations with society and environment, between sciences and humanities Mexican freshmen and senior college students. It was expected that science students would have better understanding about NoST than humanities students.

METHODS

Participants were 1037 Mexican college students in sciences and humanities (60% females and 40% males). Their ages ranged from 18 to 43 years (*M* = 22.7 years, SD = 3.9 years). At the time of the study 495 participants were freshmen and 542 seniors. PIEARCTS project has a common methodology explained elsewhere (Manassero & Vázquez, 1998). The two selected fifteen questions formats of the Questionnaire of Opinions on Science, Technology and Society (COCTS for Spanish acronimus, available on http://www.oei.es/COCTS/) were applied to the participants in the study. The variables analysed were science and humanities majors and undergraduate level (freshmen and seniors).

RESULTS

Overall results showed two important things: 1) the most of the positive indices corresponded to the appropriate phrases and negative indices to the plausible and naïve phrases, both in science and humanities students, and 2) The phrases with the highest positive indices coincided with the classification of the panel of experts who examined these items. This means that participants were able to identify appropriate beliefs that reached a consensus by the scientific community.

Beliefs about NoST in science and humanities freshmen

The comparison between science and humanities' students of the first year showed only one significant difference on the epistemological dimension, specifically in the naïve phrase referred to the scientific models used in research laboratories are copies of reality, *because much scientific evidence has proven them true*; students of both groups had negative indices, science students showed more negative rates (*M*= -.7159 ± SD .338) than humanities students (*M* = -.2698 ± SD.580, p <.0005). These findings showed uninformed beliefs in both groups of students and showed the weaknesses about these issues.

Beliefs about NoST in science and humanities seniors

In the case of seniors (see table 1) both groups of students showed erroneous concepts about technology (phrase F2_10211B_I), they agreed that technology is the application of science, the indices more negatives were presented by science students; regarding to *improve the quality of living, it would be better to spend money on technological research RATHER THAN scientific research* (F2_10421_A_I), science students showed better score than humanities seniors; concerning to the involvement of private companies in science (F2_20211D_P) both groups had negatives scores, but science students presented the most inappropriate answer for the plausible phrase. However, in the case of adequate phrase (F2_20211E_A), science senior students manifested a more informed views; in relation to who must to make the social decisions about scientific issues, just scientist or the decisions must be shared with society *(phrase* F2_C40211B_I *scientists and engineers should decide because they have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests)*, both groups had uninformed views, but again science group had more negatives results than humanities group. With respect to application of science and technology knowledge to daily life (F2_40421C_A), both groups of seniors manifested appropriate and positive views and science students had better scores in adequate phrase. Respecting scientific models, both, science students and humanities students said that *scientific models are copies of reality because much scientific evidence has proven them true* (F1_C_90211B_I). But like the freshmen, science seniors showed a more negative average than humanities students. In regard to classification schemes developed by scientists (F2_90311D_A), both groups had positive scores, though science students showed more informed beliefs than humanities students.

Table 1. Beliefs about NoST in science and humanities Students

Significant difference between seniors

Phrases	Students	Mean	Standard deviation	Significance
F2__10211B_I_Technology *(the application of science)*.	Science	-.6610	.4613	.006
	Humanities	-.4238	.5980	
F2_C_10421A_I_Interdependence (*improve the quality of living, it would be better to spend money on technological research RATHER THAN scientific research)*.	Science	.3966	.6248	.007
	Humanities	.1235	.6694	
F2__20211D_P_Industry (*S&T should not be headed by private companies (because scientific discoveries would be restricted to those discoveries that benefit the corporation (for example, making a profit). Important scientific discoveries that benefit the public are made by unrestricted pure science*)	Science	-.5000	.6088	.004
	Humanities	-.2012	.6955	
F2__20211E_A_Industry *(because corporations would obstruct scientists from investigating important problems which the companies wanted kept quiet; for example, pollution by the corporation).*	Science	.7026	.4329	.000
	Humanities	.3918	.6061	
F2_C_40211B_I_Social decisions *(scientist and engineer should decide).*	Science	-.5127	.5988	.004
	Humanities	-.2209	.6709	
F2__40421C_A_ Application to daily life *(Science classes sometimes help to solves practical problems).*	Science	.6441	.4335	.002
	Humanities	.4009	.5487	
F1_C_90211B_I_ Scientific	Science	-.4271	.4865	.004

models (are copy of the reality *because much scientific evidence has proven them true).*	Humanities	-.2176	.5587	
F2__90311D_A_ Classification schemes *(There are many ways to classify nature, but agreeing on one universal system allows scientists to avoid confusion in their work)*.	Science Humanities	.5862 .3298	.4306 .5988	.003

Freshmen and senior science' beliefs

We found some significant differences between freshmen and senior science students' beliefs. In the adequate phrase referent to *industry should not head science, because if corporations did, corporations would obstruct scientists from investigating important problems which the companies wanted kept quiet; for example, pollution by the corporation*, seniors showed significant higher scores than freshmen; in the phrase related to S&T solving everyday problems (application to daily life, F2_40421_A_I), both science groups had negative indices, but science seniors showed the most negatives. The last sentence in which significant differences were observed pertains to the classification schemes for nature that scientists use (i.e. F2_90311_D_A *There are many ways to classify nature, but agreeing on one universal system allows scientists to avoid confusion in their work)*; in this case both groups had positive views, although seniors performed better than first-years, in the table 2 is shown the effect size of differences.

Table 2. Effect size and significant differences between phrases indices of freshmen and seniors sciences.

Format 2	Effect size	Significance
F2_20211_E_A Industry *(should not head science because if corporations did, corporations would obstruct scientists from investigating important problems which the companies wanted kept quiet; for example, pollution by the corporation).*	0.7913	0.01
F2_40421_A_I Application to daily life *(S&T solving everyday problems)*	1.05	0.000
F2_90311_D_A Classification schemes (*There are many ways to classify nature, but agreeing on one universal system allows scientists to avoid confusion in their work)*.	0.7383	0.008

Humanities students' beliefs

When we analysed the beliefs of humanities students we found a higher number of significant differences between freshmen and seniors, which are shown in table 3.

Table 3. Means, standard deviation and significances among humanities first-year and last-year students related to NoST beliefs.

	First-year students		*Last-year students*		
Phrases	Mean	Std. Dev.	Media	Std. Dev.	Sig.
F2_C_10421A_I_Interdependence	-.0093	.60184	.1235*	.66946	.009

quality of life					
F1_C_20141I_I_Country's government policies	.2524	.68971	.3471*	.69219	.000
F1_C_30111G_I_ STS interaction	.3125	.62935	.3745*	.64458	.003
F2_C_40131G_I_Social responsibility information	.0031	.63717	.2317*	.65213	.004
F1_C_40161A_I_Social responsibility contamination	.1887	.70793	.3302*	.69920	.000
F2_C_60521H_I_Gender equity	.2428	.67613	.4909*	.58672	.002
F2_20211C_P_Industry	.0586	.62906	-.1265	.65302	.006
F1_C_40531A_I_Life welfare	-.2859	.58731	-.1307*	.62996	.010
F2_90111C_I_ Observations	-.3610	.50143	-.1702*	.60521	.004
F2_C_90521A_I_role of assumptions	-.3198	.56997	-.1174*	.66429	.008

*Indicates phrases where seniors got higher scores than first-year ones.

In most of the phrases last-year humanities students showed more favourable beliefs than beginners, including those sentences where both groups had scores either positive or negative, seniors had more positive or less negative scores. For example in the first phrase, F2_C_10421A_I_Interdependence quality of life (i.e. for *improve the quality of living, it would be better to spend money on technological research RATHER THAN scientific research)*, the last-year students had positive and appropriate views, meanwhile the first-year participants had negative indices. The second phrase F1_C_20141I_I is referred to how *Scientists are NOT affected by their country's government policies: because scientific research has nothing to do with politics.* Again humanities seniors had more positive scores. In the next naïve phrase (F1_C_30111G_I) about the interactions among STS, the humanities students disagree with the idea that there is just a light relationship among science and society –as shows this phrase-, they think that exist a mutual interaction between STS, although they are not so sure about the intensity between them, mainly first-year students. With regard to social responsibility with information (F2_C_40131G_I_) that is the social responsibility of the scientist to inform their findings to the general public in a manner that the average citizen can understand (*Scientists should NOT be held responsible since the public often does not seem to care. It's up to the public to learn enough science to understand the reports)*, once more seniors manifested beliefs more informed. Respecting to F1_C_40161A_I_Social responsibility with contamination: Both groups of humanities students had appropriate views and showed social responsibility, they disagree with *the heavy industry should be moved to underdeveloped countries to save others countries, they think that It doesn't matter where industry is located. The effects of pollution are global and moving industry is not a responsible way of solving pollution. We should reduce or eliminate it.* However, even though both groups had positive scores, seniors had better indices. And the phrase F2_C_60521H_I_ of Gender equity *(Women would do science somewhat differently because, by nature or by upbringing, females have different viewpoints, perspectives, imagination, or characteristics - such as patience-)*, both groups of humanities students showed appropriate belief, but first-year students had lowest indices. These results show the effect of training.

The phrase F2_20211C_P_Industry it is noteworthy that freshmen had better scores than seniors. Finally, in the last three phrases showed in the table, like F1_C_40531A_I_Life welfare (referred to *more technology will improve the standard of living of the country, because technology has always improved the standard of living, and there is no reason for it to stop now,* F2_90111C_I_ *Scientific observations will not differ very much even though scientists believe different theories. If the scientists are indeed competent their observations* *will be similar*, and F2_C_90521A_I_ the role of assumptions for the development of the theories or laws that is *assumptions MUST be true in order for science to progress: because correct assumptions are needed for correct theories and laws. Otherwise scientists would waste a lot of time and effort using wrong theories and laws*, the two groups of humanities had negative indices. These negative means corresponded to naïve and plausible phrases and even though in these cases both groups of students show uninformed beliefs, last-year students performed better than beginners.

CONCLUSIONS AND IMPLICATIONS

The results of this study allowed us to identify important NoST teaching and learning elements. This assessment is the basis to design proposals to improve the science and technology education.

In general terms the results showed that college students' beliefs were fragmented and it can be seen a lack of strength in their knowledge. In addition, the most of participants exhibited naïve beliefs and inaccurate understanding about NoST, which confirm previous investigations (Abd-El-Khalick, 2006). The subjects in which college students' had more accurate beliefs were related to social responsibility to pollution and information, and to equality of women and men in science. But they lacked experience in technology concept, scientific community feature and STS interactions.

In this research it was expected that training and experience related to science contributed to a better understanding of the NoST. These results do not support totally this hypothesis. Because working with science and humanities students, we noticed that the humanities students showed more informed and elaborated beliefs than the science ones. Only in a few cases, science students demonstrated better scores than humanities students. We observed naïve beliefs in all groups of students, but contrary to expectations, it was in the science groups where the views resulted less informed and they had lower ability to link science and technology with society. Besides science students had more naïve beliefs overestimating the role of S&T on society and minimizing the role of society on S&T; a possible explanation about these findings could be the influence of previous learning experiences and reflect more entrenched naïve views about S&T. Science students' views of NoST would have been affected by a traditional positivist approach to interpreting what constitutes science. In addition, humanities students' have a strong socio-cultural training by which these students showed a better performance in these aspects. These finding were unexpected, by which we consider that is very important to carrie out a deeply analysis of these results. The significant differences on NoST beliefs among science and humanities' Mexican students proven that students with different major backgrounds have slightly different scientific epistemological beliefs, confirming previous results (Liu & Tsai, 2008) and contrasting with those reported by Schommer (1993), since in our study science students did not have more sophisticated views about science issues. Our findings make evident that the programs of science are not taking into account important aspects of the nature of science, because the senior science students are not showing a better understanding of these issues. It is necessary to address in an explicit and concrete way these contents, as Lederman (2006) has pointed out, the nature of science contents should be presented in a reflective manner and need to be taught as other more traditional cognitive outcomes.

The Mexican science curriculum includes content on NoST such as the study of nature, science and technology, its applications and relations with society, considering benefits and problems in society and the environment. The science students' beliefs indicate a lack of substantive elements as the relationship between socio-economic, political and ethical issues with NoST aspects. On the contrary, in humanities students there were several differences among freshmen and senior, and in most cases seniors showed more informed and appropriated beliefs.

These data can be very useful because, in conformity with Liu & Tsai (2008), in this research we also deemed that understanding the students' epistemological views could offer valuable information for the design of graduate and undergraduate courses to improve students' science epistemological views and provide us with some clear direction in terms of future research and teaching proposals.

Finally, we consider that much more work is needed to develop a better NoST understanding in all college students, not only in science students, because in our society every citizen should be able to make informed decisions about those issues and then to build a better relationship with the environment.

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IS THE ATOM REAL OR BUILT? OR IS IT AN INTERMEDIATE BETWEEN THESE TWO? A WITTGENSTEINIAN APPROACH.

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Abstract: The question about whether the atom is real or built is still among us despite the scientific and philosophical efforts already made. In this work we propose a solution to this question based on the philosophy of Wittgenstein, looking on how we use language. Wittgenstein's thought is considered of crucial importance in twenty century philosophy. Despite the importance of his philosophy, which helps us to think about concepts, language and meaning, nowadays there are few contributions of Wittgenstein's ideas in science education. We challenge the idea of asking questions directly about the atom out of a model and try to put real and building in the right place in scientific practice. We discuss about models, data and natural phenomena, and try to understand them in terms of real and built. Instead of trying to answer this question, we *dissolve* it, remembering what exists and what is built in scientific practice. Wittgenstein's philosophy, as an exercise to a closer look on how we use language, is useful to understand philosophical aspects of chemistry and science education. We must not fear or be angry with either existence or building. It is only necessary to put each one of them in their right place. We think it is an interesting educational solution to this problem, as students will start to see that some usual questions may be illusory.

Keywords: Wittgenstein, Science Teaching, realism, constructivism, philosophy of language

INTRODUCTION

It is quite clear by now that Wittgenstein (2001) wrote about philosophy, more specifically the language illusions that philosophers had been chasing for some centuries thinking it were big truths. Wittgenstein's thought is considered of crucial importance in twenty century philosophy. His contribution has influenced the linguistic turn in philosophy and also many other disciplines. These contributions, like his anti-essencialist approach and his methods of pointing to language illusions where philosophers have been trying to find grounds, are still a challenge to those dedicated to an in deep understanding of his thought. His important philosophy helps us to think about concepts, language and meaning, and nowadays the contributions of Wittgenstein's ideas in Science Education research can be found in influential epistemologies inspired on his philosophy (Wickman and Östman, 2004). The questions about the existence of the atom are important in chemistry courses and teacher training courses. Our main focus is to present a contribution on this subject based on Wittgenstein's philosophy. As well as the philosopher, we want to show that some expressions in Chemistry and Science Education are misleading, and have guided us to ask illusory questions on both fields. In particular, we want to show a philosophical solution, in a wittgensteinian fashion, to the old problem of asking whether atoms are real or built, or even an intermediate between these two positions. We have no intention in finishing this philosophical question, as we are talking to a Science Education community.

It is necessary to observe at first that we, in Science Education research, are not doing any Philosophy of Science research. In fact, in Science Education many historical aspects of Philosophy of Science help us to show the way scientists do science, and these aspects are also interesting to introduce students to important questions in Science Education. Nevertheless, we are always challenged by questions from the Philosophy of Science research field. One of those is the famous question about the existence of the atom. Do atoms exist or are they constructions of our senses? Can we say that atoms are real, for example, in a scientific reality, in opposition to a naïve reality, or the dependence of our senses wouldn't allow us to do such assertions?

The first big congress of chemists took place in Karlsruhe (Nye, 1996). This event gave visibility to Chemistry, and one of the goals was to define general rules to this discipline. One of the main questions was on the divergence of the uses of terms like *atomic weight* and *atomic equivalent*. It was a philosophic question between atomists and anti-atomists, and the background was the existence of the atom. But there was no confrontation between these two groups in that moment, as chemists needed to defend their position against the mecanicist naïve realism of physicists. And this dispute has been renewed in many other flavors, like the dispute between Ostwald's energysm and Boltzmann's realism that ended in 1906 in favor of the late.

More recent disputes on the existence of the atom are about of what representation actually represents, among other topics. Ghins (2010) discusses about the applications that Bas van Fraasen does of Foucault's proposals, when the late challenges the idea that knowledge is representation. Ghins defends a scientific realism, and asserts that models do not represent *completely* natural phenomena. Giere (2006) defends a perspectivist realism, which accord to him would be between realism and constructivism. In his arguments he claims that scientific propositions are neither as objective as objectivist realists want, nor as socially determined as moderate constructivists think. The only fact collectively recognized here is that this surely is a philosophical problem because no more data will solve this old quarrel. In this work we want to analyze the questions, instead of choosing one of the answers.

REAL OR BUILT?

Before our reader accuses us of realism or constructivism, we ask for patience to read our text in full length. We will start with an ordinary question as an example of what we are going to talk, and after that, we will start thinking about our specific subject. Does Santa Claus exist? Of course not, most of human beings would answer. But if we are able to talk about him, so in some sense he exists. Philosophical puzzlement many times starts like this. A wittgensteinian answer to this question would be that we are talking about two similar, but different ways of *existing*. Concepts, models or stories do not exist in the same sense as mountains or natural phenomena. Some philosophers, when asking about this two different existences as if they were one, forget that we, human beings, invented the Santa Claus story, but we did not invent natural phenomena, although we invented ways of thinking and talking about them. And we can use the word *exist* for both, but with different meanings.

From this point we remember a curious fact about the questions of the atom existence: We don't remember someone has ever asked us about the existence of Rutherford's atom, or

Sommerfeld's atom, or any other model's atom. The question about the atom existence is always made as if it was possible to talk seriously about it out of a given model. We forget that it is not possible to ask anything about the atom out of a model. Lets us try, for example, to ask something about the relationship between electrons and the nucleus in an atom. One would immediately ask: in what atomic model? This would be so because, if we think about Dalton's atom, there is no such a relationship, once there is no electron. And these relationships would differ enormously from model to model. It is not possible to ask if the atom, out of a model, is real or built, just because there is no atom out a model. As chemists and physicists most of us keep talking about atoms without specifying a model, just because it is *implicit* in the properties that are on the subject. This leads us to the illusion that it is possible to ask questions directly about the atom.

What is built in science?

We believe no serious researcher think that any atomic model was not built. So, the atom of Rutherford is a model built by us, as well as any other atomic model. We built these models from the data available in the circumstances, and also from any other historic and scientific circumstances. These models were built to explain data, and also to understand better natural phenomena and some of its properties. So, it is an illusion to ask about the existence of the atom, out of a model, because no one doubts that all models were built. It follows that *atoms, in a given model, are built*. We must not feel that scientific knowledge is threatened because we use models as constructions. We just have to put it in the right place.

What is real in science?

At this point maybe the reader is thinking we are going to defend a constructivist approach, but this is not the case. Someone would be inclined to think like this so far in this text because, at the end, we work with science, and there is plenty evidence about the properties of the models we have built. So, something *must* exist! It is not correct to say that atoms exist, because there is no atoms out of a model, but as practitioners of experimental sciences we also don't believe that the world that surrounds us is a mere convention. So, is it possible to speak that something exists? If so, what is this? Is it a reality behind or beyond our senses?

First, is it possible to speak that the data we collect exist, in a strict sense? We don't think so. The data we collect depend upon methods of collecting data, knowledge of how to deal with numbers, charts and other way of representing, and many times it is possible to collect different sets of data from the same natural phenomenon. Our data are also built, in the sense we have to collect them, as well as we have to arrange them in a proper way of representation.

So, are our data mere conventions? Here we have to remember that there are at least two aspects of data. The first one is about the constructs and representations we invented to deal with quantities, and upon what we take data. The second is that when we take data, it is a way to represent some aspects of a phenomenon that exists without human interference. So, about the question of our data being a convention, the answer is *yes* in the sense about the way we write it, and *no* in the sense they mirror some aspects of natural phenomena. These are two different aspects, and sometimes we treat them as if they were just one. We are not defending that data are conventions, but that its representation is a convention. And we are not defending that data is real, but that it represents some aspects of a real phenomenon. The data may be seen as a mirror of some aspects of natural phenomena, but cannot be considered real in a strict sense, like the natural phenomena itself. In any case, we can say that our data is built.

But, does *anything* exist anyway? To understand better about the existence of the world that surrounds us, we have also to remember from what point most of scientific discourse has emerged: understanding natural phenomena. Natural phenomena are the only thing we can say to exist, in a straight sense. No one should doubt about the existence of natural phenomena, as well as no one usually doubts about the existence of the front door of his or her house. It is senseless to believe the existence behind or beyond our senses both to natural phenomena and our door. It is also senseless to doubt their existence. They just exist. So, it should not be necessary to ask if either of them exist. We think, thought, it is important to stress that *the only existence we can talk about, is of natural phenomena*. But the existence of natural phenomena in atomic and molecular level and the evidences about the laws of matter do not give us the right to state that the models we invented exist. Models and data are built. We must not feel that scientific knowledge is threatened because models and data are not real in a strict sense. We just have to put real in the right place, and this place, we believe, are natural phenomena, although data mirrors some aspects of it.

The illusory question

So, the question about the existence or building of atoms is put as if it was two conflicting positions, and you had to commit yourself with one of them. Or worse, maybe there should be an exhaustive mental exercise to find an intermediate position between these two, or even to find a third way of explaining the fact that we build models and are able to talk about natural phenomena. We hold that none of these positions are satisfactory, because in all of them we just forget how we use the words *real* and *built* in everyday life. And if we want to give them new meaning, let us say clearly what meaning is this. It is philosophically misleading to ask a question in a broad sense, e.g. if something is real or built, and expect a specific sense. All we need to do is to remember what is real and what is built in scientific practice, and that it is not possible to talk seriously about atoms without specifying a model.

Conclusions

The question about whether the atom exists or is built is a double illusion. What is built is the atom of a given model and data, and what exists are natural phenomena. So, the atom of, say, Rutherford’s model, is built, although the natural phenomena in atomic and molecular scale, from where both data and model were obtained, is real. The question put forth in the title cannot be answered because it is philosophically misleading and senseless. Instead of trying to answer this question, we tried, in this short work, to *dissolve* it, remembering what exists and what is built in scientific practice. Wittgenstein’s philosophy, as an exercise to a closer look on how we use language, is useful to understand philosophical aspects of chemistry and science education. We must not fear or be angry with either existence or building. It is only necessary to put each one of them in their right place. We think it is an interesting educational solution to this problem, as students will start to see that some usual questions may be illusory.

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DETERMINATION OF STUDENTS' MODEL COMPETENCE USING OPEN-ENDED AND HANDS-ON TASKS

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Abstract: Models are an important part of scientific thinking and working methods. Thinking in models enables people to communicate about difficult scientific topics and to reach a consensus. Therefore, scientific thinking and working methods cannot be learned without models (Harrison & Treagust, 2000). However, various studies have shown that most of students` conceptions of models and modeling differ from scientific conceptions (e.g. Grosslight et al., 1991). To describe scientific and everyday conceptions, Upmeier zu Belzen & Krüger (2010) have developed a theoretical structure of model competence. First of all, this theoretical structure needs to be evaluated empirically.

The aim of the presented research projects is to evaluate the theoretical structure using open-ended and hands-on tasks. These different approaches make it possible to cover different facets of model competence concerning thinking in and handling of models (White & Gunstone, 1999).

To achieve this objective, fifteen tested open-ended tasks (Grünkorn et al., 2011) were used and data were collected from a total of 1180 students (grade 7-10). The data were analyzed by qualitative content analysis (Mayring, 2007) to identify different students' conceptions of models and modeling (categories) and to compare them to the theoretical structure. A following study with two evaluated hands-on tasks (Hänsch & Upmeier zu Belzen, 2011) was conducted with four students. 135 student answers given while thinking aloud and during interviews were coded thematically (Hopf, 2001) by assigning the answers to the categories of the open-ended tasks.

The analysis of the student answers shows that the majority of the students' answers are consistent with the theoretical structure. However, the findings revealed that additional facets in the theoretical structure need to be considered. Some categories of the open-ended tasks show hands-on specific expressions.

Keywords: Models, Nature of Science, Model Competence, Open-Ended Tasks, Hands-On Tasks

INTRODUCTION

Models in science are not only resources to teach scientific knowledge, but are also scientific thinking and working tools to generate new knowledge (Mahr, 2009; Upmeier zu Belzen & Krüger, 2010). Various studies have revealed that students reflect little on their thinking in and handling of models and that they are not aware of the role models play in epistemological processes (e.g. Grosslight et al., 1991). PISA 2000 (Artelt et al., 2001) and 2003 (Prenzel et al., 2004) show that German students have difficulties in tasks where the handling of and thinking in models are essential to solving a problem. These results initiated a broad debate about the quality of the German school system (Klieme et al., 2003) whereby normative competencies were defined (KMK, 2005). In biology education, five out of thirteen competencies deal with handling models reflectively in the field of scientific inquiry (KMK, 2005).

To foster students' reflective handling of and thinking in models adequately, scientific and everyday conceptions of models and modeling need to be related and structured theoretically. Upmeier zu Belzen and Krüger (2010) have developed a theoretical structure of model competence describing skills and abilities required for this aim. This structure could serve as a theoretical basis for the development of diagnostic instruments. However, this theoretical structure needs to be tested empirically which is the objective of the presented research projects.

THEORETICAL BACKGROUND

Upmeier zu Belzen and Krüger (2010) designed a theoretical structure of model competence (Table 1) according to empirical studies (Grosslight et al., 1991; Justi & Gilbert, 2003; Crawford & Cullin, 2005) and the view of models in philosophy of science (e.g. Mahr, 2009). It entails two cognitive dimensions: The dimension 'knowledge about models' with the aspects 'nature of models' and 'multiple models' describing individual concepts that are applied when dealing with models. And the dimension 'modeling' with the aspects 'purpose of models', 'testing models', and 'changing models' which describe the handling of models concretely.

Each aspect is further divided into three levels representing different reflection levels. So far, these levels have not been described as developmental levels (Upmeier zu Belzen & Krüger, 2010).

Table 1: "Theoretical structure of model competence (Upmeier zu Belzen & Krüger, 2010)"

Complexity / Aspect	Level I	Level II	Level III
Knowledge about models			
Nature of models	replication of the original	idealized representation of the original	theoretical reconstruction of the original
Multiple models	differences between different model objects	the original allows the creation of different models	different hypotheses about the original
Modeling			
Purpose of models	describing the original	explaining investigated relationships	predicting connections between variables
Testing models	testing the model object itself	comparing the model with the original	testing hypotheses about the original with the model
Changing models	correcting errors in the model object	revising the model due to new findings about the original	revising the model due to falsification of hypotheses about the original with the model

OBJECTIVE

Since this theoretical structure of model competence (Upmeier zu Belzen & Krüger, 2010) has not been empirically tested yet, the aim of the two presented research projects are to evaluate this theoretical structure using open-ended (Grünkorn et al., 2011) and hands-on tasks (Hänsch & Upmeier zu Belzen, 2011).

Both task formats are used to determine different facets of model competence: Open-ended tasks are suitable to determine students' cognitive concrete and general conceptions of models and modeling of a larger sample (Mayer et al., 2008). Hands-on tasks are used to measure – apart from cognitive abilities – procedural knowledge and manual skills (Hamilton et al., 1997). These different approaches make it possible to cover different facets of model competence concerning thinking in and handling of models (White & Gunstone, 1999).

RESEARCH QUESTIONS

The tested open-ended and hands-on tasks were used to evaluate the theoretical structure of model competence (Upmeier zu Belzen & Krüger, 2010). Regarding this aim, the following research questions are posed:

- To what extent are the students' conceptions of models consistent with the theoretical structure of model competence?
- Which additional students' conceptions of models to the theoretical structure of model competence can be identified using open-ended and hands-on tasks?

RESEARCH DESIGN AND METHODS

Open-Ended Tasks

To answer these research questions, 15 open-ended tasks were used and tested in preceding studies for understandability and adequate operationalization to the theoretical structure (Grünkorn et al., 2011). Each open-ended task consists of a short task context, a visualized biological model, and a standardized instruction (Table 2). The tasks were designed in a way that students should be able to give answers at all levels.

Table 2. "Standardized instructions for each aspect"

Dimension	Aspect	Instruction
Knowledge about models	Nature of models	Describe the extent to which this model looks like the original.
	Multiple models	Explain why there are multiple models for one original.
Modeling	Purpose of models	Describe what purpose this model serves.
	Testing models	Explain in detail how people can test if the shown model serves its purpose.
	Changing models	Explain in detail what could have happened so that this model will be changed.

Since one student could not answer all tasks, the task pool was distributed in 35 test booklets (multi-matrix design). The study was conducted with 1180 7th to 10th-grade students aged between 11 and 19 years old to obtain student answers at all three levels. The data were analyzed by qualitative content analysis according to Mayring (2007): In an inductive approach, similar student answers were structured and categories were generated describing different students' conceptions of models and modeling. Subsequently, the categories were assigned to the three levels of the theoretical structure (deductive approach). If a category could not be assigned to the theoretical structure, it was added to the aspect of the theoretical structure. This categorization enabled a detailed description of each aspect.

To evaluate the assigned student answers, additional raters were consulted. The assigned student answers from two raters were compared and differences were discussed until a consensus was reached (Gropengießer, 2001). If a student answered in different categories or levels, all categories and levels were noted.

Hands-On Tasks

Two hands-on tasks were designed based on the process of scientific modeling by Justi and Gilbert (2002) and the theoretical structure of model competence (Upmeier zu Belzen & Krüger, 2010). The structure of hands-on tasks consists of different oral and written parts that encourage students to investigate a biological phenomenon by building their own models. At the beginning of the hands-on tasks, students generate own questions to the presented phenomenon. In order to find hypothesis and plan the examination, important information about the phenomenon is given. Resulting mental models are recorded using a drawing (Gobert & Pallant, 2000). This is followed by the construction of a model with different materials and conclusions about the hypotheses. At the end of each task students are tested whether they can integrate new information about the original in own models. The structure of the hands-on tasks was evaluated by five experts on model competence regarding the adequate operationalization of the theoretical structure and by two linguists regarding the understandability of the tasks. So far, four students (grade 7-10) solved two hands-on tasks in 90 minutes.

Psychomotor skills and verbal aspects of model competence can be determined while solving hands-on-tasks using the multi-method interview. This method consists of three components: interview, thinking aloud and videography (Wilson & Clarke, 2004). Student statements given while thinking aloud and during interviews were coded thematically (Hopf, 2001) by assigning the answers to the categories of the open-ended tasks. The assignments of the student answers to these categories were conducted by two independent coders.

RESULTS

Open-Ended Tasks

Altogether, 38 categories could be described and the majority – 35 categories – could be assigned to the three levels of the theoretical structure of model competence. Table three shows the distribution of the student answers within all aspects of the theoretical structure. If a student answered in different categories or levels, all categories and levels were noted. The category 'not evaluable' represents student answers that did not answer or his/her answer did not correspond to the question.

Table 3. "Distribution of student answers in all aspects"

Aspect, Number of students	Frequency of students' answers in absolute values (%)			
	Not evaluable	Level I	Level II	Level III
Nature of models, n=697	75 (10.8)	478 (68.6)	115 (16.5)	29 (4.2)
Multiple models, n=705	158 (22.4)	369 (52.3)	220 (31.2)	61 (8.7)
Purpose of models, n=707	35 (5.0)	363 (51.3)	337 (47.7)	165 (23.3)
Testing models, n=711	58 (8.2)	219 (30.8)	479 (67.4)	56 (7.9)
Changing models, n=713	118 (16.5)	224 (31.4)	464 (65.1)	4 (0.6)

The percentage distribution of the aspects 'nature of models', 'multiple models', and 'purpose of models' shows that most student answers could be assigned to level I, followed by level II. Level III represents the lowest share. For the aspects 'testing models' and 'changing models' the majority of the students responded at level II, followed by level I. Only a few students gave answers at level III.

Some of the student answers that could not be assigned to the theoretical structure describe three additional perspectives that need to be considered: The aspect ‘multiple models’ is understood as one original is presented by different models. However, several students (n=106) justify the presence of multiple models with different originals or evaluate the shown models for correctness, as exemplified in the following. Those student conceptions were summarized to the category ‘one model for one original’.

Student (Q352): There are different models because there are different types of gullets. Additionally, the shape of the gullet can change after some years.

Student (Q23): I think that two of the three shown models are wrong and that only one model is right.

For the aspects ‘testing models’ (n=6) and ‘changing models’ (n=24) a number of students think it is unnecessary to test a model or think that the model does not change, for instance:

Student (Q71): Why do we need to test this model of a bug? I believe that this is unnecessary.

Student (Q208): In my opinion, this model does not change. The model is final.

Hands-On Tasks

135 student statements from interviews and thinking aloud could be assigned to the categories of the open-ended tasks. Therefore, hands-on tasks can be used for the determination of model competence. In this process, the hands-on tasks confirm the additional categories of the open-ended tasks. Most students make statements on level one and two concerning models as media, as to the open-ended tasks. Additionally, the hands-on tasks lead to reflection of models as tools to generate new knowledge, since many statements can also be assigned to categories on the third level of the theoretical structure. Further, because of the construction of own models, students understand them as idealized representations or theoretical reconstructions in the aspect ‘nature of models’.

A more detailed analysis shows hands-on specific expressions of some open-ended categories. The first relate to the function of the constructed model objects. For example, different functional principles of different model objects are described on the first level of the aspect ‘multiple models’:

Student (Z41): Maybe something works quite differently with a different model. Without this cover, it could fall down.

Another hands-on expression is related to the evaluation of the constructed model objects regarding to the proximity to the original, the achievement of the purpose, creativity, clearness and economy of materials:

Student (A85) I think the model is very clever ... This is also the most logical, because less material had to be used ... The sinking model is clearer than mine.

The following student statement clarifies recognition of a solidarity facet of knowledge acquisition with models, especially on the third level of the aspect ‘multiple models’:

Student (A63): There must be different models for the spinal column because there are people who think differently. Their reasoning will be different to mine. And we help each other through our thinking.

SUMMARY AND CONCLUSIONS

Concerning the percentage distribution of student answers shown in table three, Grosslight et al. (1991) and Crawford and Cullin (2004) note similar findings. Differences can be found for the aspect ‘testing of models’, showing that most students test a model while comparing the model object with the original (level I), whereas in the study of Grosslight et al. (1991) the majority of the students test the model itself to try something out. One possible reason for the prominent conceptions in level I and II of the theoretical structure might be a more frequent use of models as a substitute for the original or as a medium for transmitting information in biology lessons (e.g. Crawford & Cullin, 2004; Van Driel & Verloop, 2002).

Some open-ended task categories show hands-on expressions: For example, many statements relate to the function of constructed model objects because student hypotheses refer to the explanation of functions. Another hands-on expression, different student evaluations of the model objects, can be explained by the individuality of the modeling process (Justi & Gilbert, 2002). In addition, solidarity facets are visible in many student statements. The involvement of students in individual modeling processes leads to the reflection of scientific knowledge. Its social and cultural character (Lederman, 1992) can be deepened using hands-on tasks. Schwarz and White (2005) speak in this context of a metamodeling knowledge.

In both research projects three additional categories ‘one model to one original’, ‘no need for testing a model’, and ‘no need for changing a model’ could be described to the theoretical structure of model competence (Upmeier zu Belzen & Krüger, 2010). Similar results on the conceptions ‘one model to one original’, and ‘no need for changing a model’ are given by Justi and Gilbert (2003) and Crawford and Cullin (2005). In order to foster students’ reflective understanding of models and modeling adequately, it is important to know about these conceptions. Therefore, these perspectives need to be considered and might be added to the theoretical structure of model competence as an additional level.

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CREATING A MORE SOPHISTICATED STUDENT VISION OF THE NATURE OF SCIENCE: A SURVEY REPORT

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Abstract: Science teaching in high schools should stimulate students to understand the philosophical and cultural implications of scientific knowledge. One way to put this principle into practice is to develop curricula using a historical-philosophical approach. However, an investigation of textbooks and syllabuses in Brazil found almost no examples of this approach. This article discusses an educational experience developed in Brazil for students in a high school physics course. The course aimed to introduce a historical-philosophical approach starting with simple student inductive arguments about facts that precede theories. In this course, we introduced new activities and discussed historical-philosophical issues to create exercises incorporating this approach. We also introduced discussions about the worldview of each issue with dialogs about history, economy, arts, and others areas of human culture. Our goal was transforms students' views about science into something more complex. This pedagogical project does not significantly modify the structure of the physics course, but simply introduces conflicts at specific points in the course. The results showed that it is a useful method for including philosophical and historical discussions beyond anecdotal stories about science and scientists to a class.

Keywords: History of Science, Philosophy of science, Nature of Science, historical-philosophical controversies, experimentation.

INTRODUCTION

This research is part of the work developed by Tekne group in Brazil. Our aim is to develop research and pedagogical projects to stimulate students in secondary schools understanding the philosophical and cultural implications of scientific knowledge. The Teknê Group works since 1993 with the historical and philosophical approach in science education throughout the production of support texts.

In order to understand the philosophical and cultural implications of science, the students need to reflect about the process of elaboration of scientific knowledge throughout history (Braga, Guerra & Reis, 2010). Thus it is important to bring discussions about NOS to science's class. As far as we are concerned, the most critical question is: How to promote discussions about science in secondary schools?

This is not a new question. Some researchers have discussed it in last years (McComas, 1998). Some of them defend that the best way to put discussions about NOS in class is to develop activities in science classes which allows students understand the NOS without discussing explicitly aspects of NOS (Abd-El-Khalick & Lederman, 2000). Others defend that teachers have to put science in scrutiny in class, so, in this way, teachers have to develop activities that explicitly discuss NOS (Abd-El-Khalick & Lederman, 2000).

These considerations led us to develop a research with important data for this debate. Therefore, our research aims to answer the following question:

Is the introduction of historical-philosophical issues together with activities putting some element of NOS in scrutiny, a path that leads students to understand the philosophical and cultural implication of science?

To answer this question we've developed and evaluated a Physics course. But before the beginning of the course we had considered some key issues:

1- The scientists path to build knowledge are complex;

2- Scientific knowledge is build "throughout" dialogues among different knowledge.

These issues were confronted with the results of a survey developed previously with 173 students who attended the course. At this moment, the students answered an opened-end questionnaire with four questions. These questions were taken from VNOS-C questionnaire translated into Portuguese (Lederman et al., 2002). The four questions selected were related to experiences, creativity in science and the difference between law and theory. This survey data have shown that 73 % of students believe experimentation is a stage of scientific method that confirms the validation of a hypothesis; 63.6% of students believed that creativity is used only in the building of hypothesis; 14% said that scientists use creativity after data collection (although they pointed that creativity is used only when scientists do not have enough data to explain one phenomenon) and only 5% of them affirmed that creativity is part of all scientists' work. It is important to mention that in the previous survey the students did not give any examples to confirm their ideas.

These considerations led us to concentrate upon the role of experimentation in science. So our aforementioned question has changed for:

> Is the introduction of historical-philosophical issues together with activities that explore some aspects of NOS a path that leads students putting the role of science experimentation in scrutiny?

This question has guided the plan and the evaluation of the Experimentation Physics course. It is important to emphasize that our purpose is not evaluate the students' visions change on science. Our goal is to create a more sophisticated vision of Nature of Science. With these ideas in mind we have planned the course.

THE COURSE

The course was carried on in an 11th grade class with 173 students divided in 5 classes. The students have two physics teacher. One of them was developed his lessons in laboratory and other in classroom. The present course was developed only in the laboratory. The students met the teacher each two weeks. The duration of each meeting was 100 minutes.

The students work in groups. Each group has four or five students. To identify each student and groups we used a code with two characters. The first one indicates the class (A, B, C, D and E). The second one shows the number of student in class.

To evaluate the course we chose a qualitative research approach. Photos and notes were collected during the lessons by teacher and another researcher. It is important to note that the teacher was part of the research team with other researchers.

The theme of the course was Thermodynamics.

We selected a specific historical moment to develop this work. This selection comes from a short book written by Teknê Group about “Lavoisier and the Enlightenment Science” (Braga et al, 2000)

We considered the data of another research develop by Tekne group about the introduction of historical controversies in science lessons to decide which moment to choose (Braga, Guerra, Reis, 2010). The data of this research led us to consider one interesting historical controversy that occurred in the 18th century: the Caloric Theory versus Phlogistic Theory.

How this controversy would contribute to the debate?

This controversy took place in the 18th century, so, it is important to note:

- Newton had unified the terrestrial and celestial Physics. And for many philosophers and scientists the Newtonian Physics model turned to be a good way to explain the world.
- The pharmaceutical and mineral industries growth stimulated the development of experimental science, like chemistry and electricity.
- Chemistry had in its framework elements of alchemy.
- Lavoisier, in France, and Priestley, in England, were investigating gases. They developed experiments to isolate new gases;
- Priestley and Lavoisier rejected metaphysics argument in science. Both believed that experimentation was the best way to build theories;
- Priestley explained his experiments based on the Phlogistic Theory. Lavoisier rejected this theory. For him, was necessary to eliminate the alchemy from chemistry. Therefore, it was necessary to build a new framework for chemistry and a new nomenclature to eliminate the past.

So controversy allows us to discuss with students the context in which Lavoisier and Priestley lived and worked led them to different ways, to different ideas. Because in the dialog of scientific knowledge with cultural context, theories did not determine the results of experiments, neither experiment determines theories (Hacking, 1983).

To put these arguments in evidence, along with the controversy discussion developed by teacher, the students read, at home, a book (Braga et al, 2000) discussing the controversy and in class they conducted some experimental activities that explicitly the difference between law and theory.

The activities:

1- **Solid expansion**. Doing the experiment the students obtain the law of expansion of solids. But it does not explain why the solid expand. So we discuss the difference between why and how.
2- **Calorimetric experiment**. Doing the experiments the students determined the relevant parameters to determine the heating of a body, but it does not explain what is transmitted between the two bodies. So we use this moment to discuss with the

students that with caloric theory and phlogiston theory was possible to explain what is transmitted between the two bodies.

3- In the discussion students showed some discomfort with the narrative of the controversy. They wanted to know who, Lavoisier or Priestley, built the right theory. When the teacher told that both theory are today considered wrong, and that some name gave by Lavoisier to the chemical elements, like oxygen, had a significance which do not make sense today, the students were impressed with these discussions, they claimed by a truth.

   A few students' comments were:

   "experiments should prove which of these two hypotheses was wrong. Scientific knowledge´s based on laws and theories, and theories were accepted by experiments. Rutherford proved his theory about atomic model before set up an experiment to prove it." (C4)
   "the experiments should show which of these two hypotheses is right or wrong" (E34)

4- Given this outcome, after these two activities, and before the controversy narrative end we developed with students two activities that do not have content embedded. We decided to make the aspects of NOS we wanted to discuss with students more explicit.

The first activity was the black box activity; with this activity we discussed the role of models in the scientific knowledge.

With the second activity we put the experimentation in science in scrutiny. The students received a set of wood pieces to build a figure. But with these pieces they could build different figures. So with the same pieces they could build different models, but not any model, because they could not excluded the pieces. The teacher discussed these results and compared them with science experimentation. If the data tell something to scientists, they could not ignore the pieces, but if the data do not answer completely the problem, they have to consider others parameters again.

CONCLUSIONS

After 45 days the students received the four questions that they have answered in the beginning of the course. The results of this survey showed that 62.5 % of students believe that experimentation is a stage of scientific method which confirms the validation of a hypothesis.

"It is the attempt to prove one hypothesis through instruments" (B4).

"It is a fact to be observed in laboratory with a premise, such as the hypothesis test". (D14)

37,5% of students affirm that the creativity is used only in the building of hypothesis.

"Yes. In the hypothesis elaboration, they use imagination and creativity, and after that they could make the experiments". (B5)

"Yes, because they use creativity as a starting point, but always based in scientific observations". (A6)

22.5% the students argued that creativity is part of all scientist´s work. For instance, some of them argue:

“It is something very important, because there are a few obvious things and it is necessary to be open to different opinions “not-so-obvious”. We believe the scientist uses imagination and creativity in all steps, but in some more carefully than others” (A15).

“Yes, in the Project and planning, and after data collection as well. Creativity is needed to create a productive form of data collection and after this data collection to transform the data into ideas. For instance, Galileo turn up the telescope to the sky to visualize something never seen before. Another example is analyzing a ball in movement, it is not only the velocity data collection and its standard deviation, but it is necessary transforming these numbers in an acceleration concept” (E8).

For the difference between law and theory we noted that 27.5% answered the question in the same way that they had answered in the beginning of the course. For this group law is a theory which the scientists had proven with experiments. In the same question, 42.5% argued that theory explain a phenomenon while law describes a phenomenon.

“Yes, when we describe how the things dilate with the variation of temperature we have a law, when we explain this phenomenon with atomic movement we have a theory” (C4).

20% said that law is invariable while theory is variable.

“Theory is an idea accepts by scientists, but always it could be changed. Law could not be changed. Examples: String theory could be change but Gravitation law could not be changed”. (E8)

When we compared the two group of answers and confronted them with the researcher´s notes obtained during the course, we realized that the course have somehow provoked disturbance in the student´s vision of science. In the previous questionnaire the answers were basic without examples that support them. At the end of the survey the answers were more elaborated and the students gave some examples to support their ideas.

In the examples gave by the students something was highlighted for the researchers: 29% of the students who declared that experimentation is a stage of scientific method confirming the validation of a hypothesis used the same example to confirm their ideas. They cited the Brownian movement and the Rutherford experiment as examples to confirm that experimentation is just a way used by scientists to ratify their hypothesis. When we investigated why these groups of students gave the same example, we realized that these were examples that their Physics theory teacher (the one who develops the other three classes) used to prove that the true theory to explain Thermodynamics is the Atomic theory. In an interview with this teacher, he revealed that in beginning of the course he discussed the atomic model, starting by the Greg model and finishing with Rutherford experiment. In his opinion, this is a crucial experiment that confirms the atomic hypotheses. After that, he discussed with the students the Brownian movement and used it like a macroscopic experimentation to prove the existence of a microscope element, the atom.

These results showed us two things. First one the introduction of historical-philosophical issues together with activities that explore some aspects of NOS in scrutiny is a path that leads students to understand the philosophical and cultural implication of science. The historical examples seemed not be sufficient to put science in scrutiny.

It is not easy to discuss NOS. The students have some ideas about NOS that they build throughout their schooling and these ideas are everyday reinforced by teachers. This conclusion does not mean that it is impossible to provoke disturbance in the NOS visions in the students. Our research showed us that the lessons described here were an opportunity for those students to reflect about science. They did not change their vision from a suppose naïve idea to an adequate one but their vision became somehow more complex.

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MISSING LINKS IN THE EXPERIMENTAL WORK: STUDENTS' ACTIONS AND REASONING ON MEASUREMENT AND UNCERTAINTY

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Abstract: Over the past 25 years, a number of studies have offered valuable insight into the concepts of students concerning the handling of measurement data and uncertainty. They helped introduce a number of new approaches to the introductory laboratory. However, since most of the studies remain on a theoretical, cognitive level in their method of inquiry and resolution, it seems appropriate to ask: How far have we come to understand and assist students in the problems they face when *really conducting* an experiment? In our view, this implies not only their acquisition of a theoretical concept but also their understanding of the role of uncertainty in scientific measurement and experimental inquiry in the *process of real experimental handling*.

To assess this reasoning *in action* rather than the reasoning *on action*, 32 students were surveyed in a triangulation study. They were first asked to fill out an online survey about a simple experimental task, EXP1. Subsequently, they were observed by video recording conducting an experiment, EXP2, which was very similar to EXP1, in the laboratory. After the survey and the laboratory task, they were interviewed on their reasoning using the video recordings. We found that reasoning in the survey deviated considerably from that in the laboratory task. An important factor of the students' difficulties in the second task was due to missing connections between the different aspects of experimental research. These results, which are part of a larger study on students' reasoning, of the analysis of the corresponding instructive literature and of the historical evolution of the mathematical methods concerned, influenced the design of a *model of action-guiding cognitions*.

Keywords: measurement, measurement uncertainty, measurement error, experiment, students' understanding of measurement

BACKGROUND, RATIONALE, FRAMEWORK, AND PURPOSE

Studies of Seré and Larcher (1993), Lubben and Millar (1996), Buffler *et al.* (2001), Volkwyn *et al.* (2008), and others, have brought valuable insight into students' understanding of measurement, especially where the handling of data and calculation of uncertainty are concerned. However, all these studies employed written surveys to assess the students' notions when discussing a specific (theoretical) action taken in the laboratory. Consequently, we have to raise the question whether these cognitive aspects alone can offer an extensive exploration of the problem. Maisch (2010), for example, indicated that students performed very differently depending on whether they where asked to conduct, design or solely execute an experimental task in the laboratory. It seems therefore reasonable to assume that the differences might be even more apparent when comparing the reasoning given *on* a theoretical laboratory situation to those that are given and become effective *in the conduction* of a real laboratory task. (Within the social sciences, the gap between the two concerning everyday life situations has brought forth a whole new branch of research.)

The leading research questions that can be deduced from this are therefore: What notions on the handling of data and their uncertainty can be observed in students' activities in the laboratory, and how do they correspond to their theoretical arguments on a similar situation? How can this reasoning be described in order to gain further insight into the students' notions and learning difficulties? What information can be drawn from this to influence the design of a laboratory that includes adequate teaching methods about the nature and the handling of measurement data and uncertainty?

METHODS

In a qualitative study, 32 physics students were surveyed in a three-step methodological design. All students were in their third year of study and thus had concluded one year of intensive laboratory introduction in different fields of physics. As in prior studies, and based on the instrument developed and described by Buffler *et al.* (2001), the students were first asked to fill in an (online) questionnaire on a mechanical experiment. The questionnaire guided them through different questions and situations requiring decisions in the evolution of a fictional experimental process. We used the same context as Buffler *et al.* (2001), in which a ball rolls down a (fixed) slope and hits the ground after travelling some distance d, leaving an imprint on the floor. The length of the trajectory here obviously depends on the height h of the starting point on the slope. All items of the questionnaire (e.g. for the requirement of another reading, the choice of the result of a measurement series or the comparison between different data and data sets) required an assessment of the presented data and especially their uncertainty.

After finding the results of the survey in good agreement with prior studies (e.g. Buffler *et al.* 2009), we extended the investigation to a practical task. In this second step of the triangulation study, the students were asked to conduct a very similar experiment in a practical laboratory task. The major difference between the two was that the variable parameter was not the height of the effective slope, but its shape that could be formed to different shapes of a curvature. The students conducted the experiment in small groups of two or three. The actions of the students were videotaped but not closely observed by another person in order to establish a situation as similar to the typical first year laboratory as possible.

Following the practical laboratory task, the student groups were questioned on their approach to and proceedings during the task. Clips from the tape recordings were shown during the discussions for mnemonic and transparency reasons. All questionnaires, videos and interviews were evaluated using a content analysis approach, while the latter were also supported by hermeneutic methods in the richer parts of the discussions.

RESULTS

The results of the studies provided a more precise description and understanding of the students' reasoning on action, as well as valuable insight into the difference between their reasoning on action and reasoning in action as well as the reasons for this divergence.

Description of the students' notions by means of the Model of action-guiding cognitions

The results of the study showed a sophisticated cognitive analysis of the situation by the students. In almost all cases they were able to give plausible arguments concerning the notation of results, the number of necessary readings or the routines of data calculation. The discussion of the uncertainty of measurement played only a minor role in their arguments and decision processes. For example, less than a third of the students referred to the limited precision and accuracy of the measurements when comparing different results, or when comparing them with a reference value. The uncertainty of the result in the latter cases was mostly established by estimating the deviation of the result from the reference value. These results confirmed the findings of prior studies by Séré & Larcher (1993), Buffler *et al.* (2001), Campbell *et al.* (2001) and Volkwyn *et al.* (2008) and gave some additional insight as to how the students would assess the accuracy and precision of their data if they did not use the concept of uncertainty. Rather, they employed arguments concerning the numerical values only, different kinds of rules etc. All in all, five different areas of action-guiding cognitions were isolated where students drew their information from in order to answer the questions. Those five areas contained references to either:

- the analysis of the experimental realization,
- the consideration the process of data production,
- the conduction of evaluation procedures,
- the result-based comparisons to a reference value or
- the application of normative rules

These categories gave rise to the *model of action-guiding cognitions* described above and presented in **Erreur ! Source du renvoi introuvable.**. (Four puzzle represent the first four categories and highlight the need of interconnection between them. The fifth forms a framework of formal-normative rules.) The results were also supported by an accompanying study of 151 physics students at German universities who were asked to fill in the online questionnaire as well. This was done to check the results of the triangulation study for (e.g. regional) reliability.

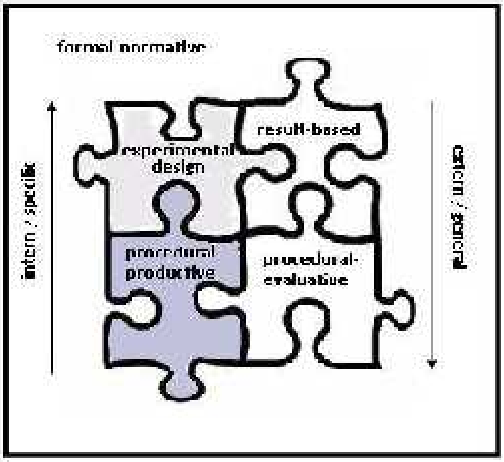

Figure 1: Model of action-guiding cognitions in the experimental context.

To illustrate the five areas of the model, we can use examples from the questionnaire. For instance, the students were asked to decide and justify whether they would repeat a measurement or leave the result to the one measurement already obtained. In the formal-normative frame focusing on the formal and theoretical aspects of experimental work – like rules, routines and boundary conditions – a typical answer would be*: „One always has to conduct any experiment three times."* A result-based argument would rather focus on the obtained numerical result of the measurand, e.g.: *„No, my result is close enough to the literature value,"* or *„I would measure again to check my result."* In contrast, a procedural-evaluative argument would focus on the evaluation routines, e.g.: *„I would repeat the measurement to get enough data for the calculations of a mean (and its uncertainty)."* In the procedural-productive area, an argument highlights the origin and history of the obtained result: *„I would repeat it if I knew that something happened during the previous measurement or if it showed some uncertainties / statistical fluctuations."* Lastly, the area of the experimental design focuses on the significance of the experimental realization: *„Probably the electric current will not stay constant all the time, so it would be wise to repeat the measurement a couple of times."*

The model proved helpful in understanding a new aspect of the students' difficulties in their understanding of the handling of data and measurement uncertainty that had not been elaborated on by former studies. It showed that not only could those different areas be distinguished in the students' reasoning but also that almost no argumentative links between the different areas were drawn in the students' answers.

Of course, one might argue that it was not mandatory to cover all or even many of the areas in every argument on measurement data and uncertainty. However, the lack of links between the five areas indicates more extensive difficulties. Those difficulties become more obvious when consulting the further results of the triangulation study. The results show that the missing links between the five areas run deep not only in the situative argumentation but in the students' understanding of the matter.

Comparison of reasoning on action and reasoning in action: missing links

The results of the second part of the study were thus quite unexpected. While all but three of the 32 students had argued in the written survey that the experiment had to be conducted more than once, the practical task showed distinctly different results. Only four out of 13 groups actually conducted a reading of the same shape of the curvature more than once. Even more surprising was that in none of these four cases this approach was heralded by any discussion on the experimental set-up, on the expected data fluctuations or even general remarks on experimental methods, let alone measurement uncertainty. Of those four groups, one decided on a threefold repetition due to some rule that “you always conduct three runs” and the repetitions of the other three merely happened by chance, e.g. because the experimenters could not agree on the result of the first run and decided to take another roll – only to notice that the second roll agreed with neither of their expectations. Just the same, the discussion of uncertainty played yet a minor role in most of the written surveys, however, in some or the other form it appeared in about half. On the contrary, none of the 13 groups observed discussed any aspect on the uncertainty of the data collected.

Protocols of the real experimental task in the triangulation show that in some cases the students had all relevant information of the different areas at hand, yet failed to put them together into a coherent picture. (That is why the design of the model was chosen as a puzzle.) In group 3, for instance, one student commented on the experimental design (which was purposely designed to be very unstable): “The belt [adjusting the curvature] is always slipping off.“ They also realized that the experimental process failed to produce stable results and employed different rules of thumb on the data production and evaluation processes. Yet, when one student suggested repeating one of the measurements for the same shape of the curvature, the other two could not see any reason for it. Moreover, they all predicted the repetition measurement would reproduce the results already obtained during the second check-up, e.g. stating: „I hope it will come out the same!“ At the end, with all information close at hand, yet failing to piece it all together, they were completely puzzled: „Okay – I really wonder why that happened just now.“ – „Me too – beats me.“

Further factors we could determine as influential on the students' practical performance concerned their personal or emotional state of mind. One group, for example, was unable to deepen their rudimental insight into the difficulties of the situation because one of them showed a very low frustration tolerance, causing her partner to become very anxious to present ad hoc solutions without subjecting the thought-provoking impulses to close scrutiny. They thus failed to come to the heart of the problem and discuss the uncertainty involved, as the first student was too easily frustrated and the second too eager to keep her in good spirits. Other important factors mentioned by the students in the follow-up interviews concerned the pressure they felt in a common laboratory task like this one to come up with a proper conclusion after a given (and often too short) time. They admitted that this pressure usually made them adjust their results somewhat to meet the assumed requirements.

CONCLUSIONS AND IMPLICATIONS

Our study concludes that there are many more factors apart from the cognitive ones that influence students' notions on the handling of measurement data and their uncertainty. In our view, those factors are closely related to the way in which we present the experiments in the introductory laboratory and the teaching of physics. The experimental tasks often contain a closed question, they are mostly context-independent and design-free, i.e. the aspired results are often known *a priori* and the tasks commonly do not illustrate a scientific problem but a surgically separated phenomenon. The experimental set-up in most cases is given within the texts and does not allow for or even stimulate any enhancements by the students. As the representation of students' notions by the model of action guiding cognitions show, the links between the areas are often missing, resulting in a poor apprehension of the complex experimental situation in a real laboratory task. Laboratory tasks and especially laboratory introductions to the handling of measurement data and uncertainty should therefore emphasize those links and support students to construct a coherent and complex understanding of the experimental situation. So far, introductions to data analysis in textbooks and in the teaching of physics are most likely to resemble a surgical simplification of the problem and promote rules of thumb that are not rooted in the consideration of the experimental set-up or situation at hand. Given the results of our study, future developments of the physics laboratory should take those factors into account – not only to aim at the transfer of experimental routines, but also at a sound understanding of the connection between different aspects of experimentation. As Buffler *et al.* (2009) point out, these connections are just as relevant when it comes to the understanding of the nature and the handling of measurement data and their uncertainties.

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KEY TEACHER'S ROLES IN SUPPORTING THE CO- CONSTRUCTION OF STUDENTS' KNOWLEDGE IN MODELLING-BASED TEACHING CONTEXTS

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Abstract: Modelling is a key process in the development of scientific knowledge. In order to conduct a more authentic science education, it is advocated that it should be conducted from a modelling-based perspective. However, the conduction of modelling-based activities in a way that really results in students' learning is not an ordinary task for teachers (who, in general, do neither discuss such a teaching approach in their education process nor experience it as students). In this paper, some data from a modelling-based teaching of solubility which occurred in a regular classroom in Brazil are analysed aiming at discussing the following research question: What are the key teacher's roles in supporting the co-construction of students' knowledge in a modelling-based teaching context? From such a discussion, relevant implications and recommendations for science teachers interested in based their practice in a modelling approach are also proposed.

Keywords: modelling-based teaching, co-construction process, teacher's role.

INTRODUCTION

Modelling in Science Teaching

There has been a general agreement that science education must be closer in terms of process to the practice of science (Gilbert, 2004). As modelling is one of the essential processes in producing, validating, and disseminating scientific knowledge (Gilbert, Boulter, & Elmer, 2000), some science education researchers (for instance, Boulter & Gilbert, 2000; Clement & Rea-Ramirez, 2008) have emphasised the importance of model-based teaching and learning as a way to stimulate scientific understanding. This is so because such a teaching approach fosters students not only to create their own models, but also to assess their models, those produced by their colleagues, and those introduced by the teacher. As an outcome of this process, they can build their knowledge from the establishment of relationships between multiple ideas, as well as understand modelling and its role in the development of scientific knowledge. Therefore, modelling-based teaching also contributes to actively engage students in their learning process, as well as in doing and thinking about science.

In one of the first attempts to shed light on the process of learning via model construction, Clement had proposed a Model Construction Cycle that represents a cyclical process of hypothesis generation, rational and empirical testing, and modification or rejection of a model (Clement, 1989). According to him, such stages were experienced by scientists, but could have relevant implications in science education if the cycle could be used to describe the process that students should experience when learning scientific models. Thus, he claimed the Model Construction Cycle should be used as a basis for designing instructional activities aiming at promoting the learning of scientific models.

In a more recent publication, Clement (2008b) presented a new version of this cycle renamed GEM cycle (model generation, evaluation, and modification). Then, students' learning process was described as constituted by three main aspects: students' initial ideas that base their first model; an evolutionary sequence of models and revisions; and discrepant questions or events that provide scaffolding which enable students to modify their models. This last aspect involves an interaction where the teacher and the students work together to construct and evaluate mental models of a target concept, which Clement named *teacher-student co-construction*.

By analysing what philosophers of science say about how scientific knowledge develops (Nersessian, 1999; Vosniadou, 2002), as well as the work of scientists who have significantly contributed to such a development, Justi and Gilbert (2002) identified some elements and organised them in a diagram (named Model of Modelling) that favours the discussion of how scientists perform the modelling process. It was also inspired by Clement's Model Construction Cycle, but tried to complement it by either introducing new elements or making additional relationships between all their elements explicit. According to it, modelling is comprised of four stages: *elaboration of the initial mental model;* e*xpression of the mental model* by using any of the modes of representation (concrete, visual, verbal, virtual, mathematical, and gestural); *tests of the expressed model* through mental and/or empirical experimentation; and *evaluation of the final consensus model*, that is, the identification of the scope and limitations of the model, which occurs from both contrasting the model with its aims and trying to use it in distinct contexts.

In the last years, our research group have been investigating modelling-based teaching from the 'Model of Modelling' diagram perspective. We have developed teaching sequences comprised of several related activities for a series of chemical topics, which have been applied in regular classes. By participating in these activities, students are involved in all these stages in order to build their knowledge. The use of such activities characterise a socio-interactive constructivist teaching context (Vygotsky, 1986) in which knowledge build occurs from student-student and student-teacher interactions. We recognise that, in specific moments of the process, it is essential that the teacher interact with students in order to favour and foster their engagement in the process. When such an interaction results in students' learning, we say that teacher-student co-construction occurs.

Teachers' action in modelling-based teaching

Some of the main necessary conditions for the occurrence of students' learning are the teacher's own competence in models and modelling, and his/her pedagogical content knowledge (PCK) on this area (Justi & Gilbert, 2002; Justi & van Driel, 2005; Núñez-Oviedo & Clement, 2008). However, previous attempts to characterise such knowledge (Crawford & Cullin, 2004; van Driel & Verloop, 1999) showed that teachers' practices rarely include modelling activities, mainly because they are not competent in this area.

Teachers' PCK related to the conduction of modelling-based activities are different from those involved in ordinary traditional teaching situations. This is so mainly due to the complexity of both the modelling process itself, expressed, for instance, by the dynamic and non-linear relationships in each stage and between different stages, as well as by the conduction of the mediating process.

Some previous studies (Justi, Chamizo, Franco, & Figueirêdo, 2011; Justi & van Driel, 2005) have shown that teacher's PCK on modelling include comprehensive elements like their: general view on modelling-based teaching; knowledge and skills required for producing modelling-based teaching activities; knowledge and skills required for conducting modelling-based activities; general view about how students reason and build their knowledge when participating in modelling-based activities; and knowledge and skills for accessing students' knowledge and skills developed in such a context. Therefore, in order to support teachers' education from this perspective, it is necessary to deeply investigate each of these elements of teacher's PCK.

RESEARCH QUESTION

In this paper, part of the results of an investigation conducted in a modelling-based teaching context is discussed. In particularly, it focuses on one aspect of teachers' knowledge and skills concerning the conduction of modelling-based activities: their actions in favouring knowledge co-construction. The following research question is addressed: What are the key teacher's roles in supporting the co-construction of students' knowledge in a modelling-based teaching context?

METHODOLOGICAL ASPECTS

Context and Sample

A set of modelling-based activities was developed from the Model of Modelling diagram perspective to support the teaching of qualitative aspects concerning solubility to 15-16 year-old students (Mozzer & Justi, 2009). In such a teaching sequence, students are asked to express their mental models by using two modes of representation: concrete mode and analogies. Students perform the activities in groups. During the group discussions, sometimes they also interact with the teacher in order to discuss their doubts or asking his/her questions about the content of their discussions, the codes of representation they used in producing the concrete model, and the aspects of their analogies that has not been clearly expressed. Moreover, after each activity, the teacher conducts a class discussion in which each group presents its ideas/models, justifies them, and answers colleagues' questions about them. It is exactly in the context of such discussions that the co-construction occurs. Therefore, the discussions do not aim at correcting students' models. Rather, they aim at (i) discussing the coherence of the models in the light of both the available information and students' previous knowledge, and (ii) favouring students' own questioning about the proposed models.

Such activities were applied in a regular class comprised of 36 students in the last month of the academic year. They had already studied properties of substances and chemical bonding around 8 months before, but from a traditional approach. As far as our data showed, they had several improper conceptions about both topics and none of them showed any previous acceptable understanding about how a substance dissolves into another. Moreover, they had previous experience with neither modelling-based activities nor investigative experimental activities. In all lessons, students have worked in groups comprised of 5-6 students.

The chemistry teacher guided the whole process. As she had no previous experience with modelling-based teaching, before the starting of the study, the third author met her twice. In such meetings, they discussed about the teaching context, the students' previous ideas related to the topic, the modelling-based teaching from the Model of Modelling diagram perspective, students' drawing of analogies, the relationships between analogies and models, and the conduction of the modelling activities. So, these meetings were essential in order to improve the teacher's understanding on both the modelling-based teaching process and the purpose of our study. The teacher has participated in both the meetings and the lessons with great enthusiasm.

Data Collection

All lessons were video-recorded. The videos focused on the discussion between the students in their original groups and those between the students and the teacher. All the moments when the teacher interacted with a given group of students (for which we were able to record most of the discussions) were transcribed verbatim.

Data analysis

In analysing the transcription, we have identified specific moments in which co-construction occurred. A deeper analysis of such moments made it possible to classify all the teacher's actions in terms of their function in the co-construction process. This was done independently by all authors and some disagreements were discussed until they were solved. Then, such categorisation was used to support the discussion of the research question.

RESULTS

The main teacher's roles in supporting the co-construction of students' knowledge in modelling-based teaching contexts could be organised into five groups of actions. They are presented in no specific order.

Group 1: Organisational actions.

Although they were important in all teaching activities, they have to be emphasised in modelling-based ones because, in such a context, they aimed at favouring the participation of the students in the activities and the expression of their ideas – elements that are essential for the occurrence of co-construction.

For instance, during Activity 2, when one of the groups was producing a model to explain the dissolving of the powder juice in water, one student, who seemed to be a leader in the group, said:

> *I think the juice and the water mixed with each other due to the 'natural' movement of water.* (S1)

Apparently, his colleagues have agreed with him, and continued discussing macroscopic characteristics of the system related to the intensity of the colour. Some minutes later, the teacher, who was following the discussion, asked the whole group:

> *Do you agree with him about the role of the water 'natural' movement?*

Although hesitating, one of them said:

> *There may be something more because… why don't the particles go down in a while?* (S2)

The discussion continued and the teacher continued to provide an incentive for all the students to participate in the discussion, which was essential for encouraging them to express their ideas. This resulted in a significant improvement on their model, as well as in making them think about the relationship between the macro system and a sub-micro model that could explain its behaviour.

Group 2: Actions that favour the expression and discussion of students' codes of representation.

Such actions always occurred when students produced concrete models, and they were motivated by two specific reasons: when the teacher has realised a given code of representation might be associated with students' misconceptions, and when the ideas represented in a model were not clear.

Moreover, when students produced analogical models, the teacher has asked them about the similarities between the compared domains. In some sense, this means to ask about codes of representation because students could explain the structural basis of their representations. For instance, group 2 compared the chalk system with the class in different environments. According to them,

> *It could be the class in the classroom and here, in the laboratory. Here, each group is like a grain of chalk and the groups are not so close to each other. In the classroom the students, like the chalk particles, were closer to each other. Here, in the lab, we are separated in groups, and in each group a given number of students is kept together.*

When explaining the similarities between the two domains, the students were able to clearly express how they were visualizing the sub-microscopic aspects of the system. As the ability to move fluently between the three levels of representation (the macroscopic, the symbolic, and the sub-microscopic ones) is essential to foster a full understanding of chemical phenomena (Gilbert, 2005), questions concerning students' views on the relationships between them tends to favour students' knowledge construction.

Group 3: Actions that favour the expression and discussion of students' previous ideas.

Students' previous ideas are essential to support the building of their initial models and, sometimes, the testing of them. However, very often they do not remember adequate previous ideas, that is, those that may be related to the context in discussion. Other times, it seems that they try to guess without reflecting on their answers. In both cases, teachers' questions about the meaning of such ideas may help students to critically analyse them. For instance, one of the students said both phenomena (water + piece of chalk, and water + powder grape juice) could be explained by the density of the materials. Then, the following dialogue occurred:

T: *Which one is denser: the piece of chalk or the water?*
S5: *The piece of chalk.*
T: *And which one is denser: the powder juice or the water?*
S5: *It should be the powder juice because it sank.*
T: *And what did happen with the piece of chalk?*
S5: *It did not dissolve.*
T: *And with the juice?*
S5: *It dissolved.*
T: *So, how does density explain the phenomena?*
S5: *It doesn't explain. There should be something that is different from one system to another…*

Here, the teachers' questions made the student analyse the phenomena based in his previous ideas. This supported his following conclusions: (i) his ideas were not adequate to explain them, and (ii) the phenomena were not caused by a given characteristic of the material introduced into water, but by a characteristic of the system (that is, something related to the material and the water).

Group 4: Actions that favour the expression and discussion of students' understanding of empirical evidence.

In Activity 3, when students mixed the powder grape juice in water without stirring the system, many of them have showed to be confused by the sequential observations related to the slowly dissolving of the powder juice. Then, the teacher asked them to conduct the experiment again, and questioned each of their expressed observations or comments. This resulted in students using the empirical evidence as sources of information for testing their previous model and producing a new one.

Group 5: Actions that favour the expression and discussion of students' current ideas and models.

Such actions were very common when the teacher interacted with each group and, mainly, when she conducted the final discussions in each activity, that is, when she coordinated the presentation of each group's model to the whole class and the following discussions (when students from different groups argued with each other about their models). In such moments, the teacher has not put the ideas of one student directly against those of other students. On the contrary, she has tried to favour the expression, detail, and justification of each student' ideas. This also resulted in more interactions between the students. From them, students could establish new relationships between their ideas, thus constructing their knowledge.

CONCLUSIONS

In this study, we have identified five groups of teacher's roles that support the co-construction of students' knowledge in a modelling-based teaching context: organisational actions, actions that favour the expression and discussion of students': codes of representation, previous ideas, understanding of empirical evidence, and current ideas and models. This evidences that the teacher's roles go beyond the use of discrepant questions (Rea-Ramirez & Núñez-Oviedo, 2008) or promoting "students to contribute to a discussion with ideas that are contradictory to each other" (Núñez-Oviedo & Clement, 2008, p. 117), as it was proposed in some previous studies. On the contrary, this identification and the analysis of the complexity involved in some situations in which they occur highlight the importance of teachers mediating the learning process, but simultaneously giving students the chance to act in the process. Moreover, teachers should pay special attention in order to identify moments where it is essential to change the focus of a given discussion or to foster students' thinking in a different level (which is particularly important in chemistry teaching because students tend to keep the discussion into the macroscopic level).

Therefore, teachers' educational process should include opportunities for understanding the importance of their actions that can favour the co-construction of students knowledge in modelling-based teaching contexts, developing the knowledge that support such actions, and practicing them. This seems to be a great challenge for science teachers' educators due not only to the complexity of the knowledge characterised in the previous paragraph, but also to the general inexperience of teachers in modelling. However, we believe the characterisation of teachers' actions we presented here can support the proposition of specific activities that may foster the development of teachers' PCK on modelling.

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FORMAL ANALOGIES IN PHYSICS TEACHER EDUCATION

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Abstract: Reasoning by similarities, especially the ones associated with formal aspects, is one of the most valuable sources for the development of physical theories. The essential role of formal analogies in science can be highlighted by the fact that several equations for different physical situations have the exact same appearance. Coulomb's law's similarity with Newton's, Maxwell's application of fluid theory to electromagnetism and Hamilton's optical-mechanical analogy are some among many other examples. These cases illustrate the power of mathematics in providing unifying structures for physics. Despite the relevance of the subject, formal analogies are rarely systematically approached in physics education. In order to discuss this issue with pre-service physics teachers, we planned a lecture and designed a questionnaire with the goal of encouraging them to think about some "coincidences" in well-known formulas and to give reasonable justifications. The details of this activity and its main results will be presented. Overall, the outcomes show that although the participants already knew each one of the given formulas, the majority of students were not able to identify deeper similarities between them. The analysis of the students' answers to the questionnaires and to the questions posed during semi-structured interviews allows us to propose a set of categories (levels) to classify the quality of analogy perception.

Keywords: Formal analogies in physics, Analogy perception, Pre-service physics teacher education

IMPORTANCE OF ANALOGIES IN PHYSICS

And I cherish more than anything else the Analogies, my most trustworthy masters (Kepler, quoted in Polya, 1954, p. 12).

Reasoning by similarities (analogy) is one of the greatest sources for the development of physical theories. The essential role of analogies in science can be highlighted by several historical examples: Rutherford's planetary model of the atom, Coulomb's law's similarity with Newton's, Carnot's comparison of heat engines with waterfalls, Thomson's analogy between heat and electricity, Maxwell's application of fluid theory to electromagnetism and Hamilton's optical-mechanical analogy are some among many others. In its essence, analogy is similarity on a more conceptual level, since it is strictly dependent on the intentions of the thinker (Polya, 1954). According to Gentner (2002), the "basic intuition behind analogical reasoning is that when there are substantial parallels across different situations, there are likely to be further parallels" (Gentner, 2002, p. 106). In this sense, analogical arguments can be used to generalize concepts, theories and methods so that they "become applicable to classes of objects which are not of the same kind as those to which they originally apply" (Tzanakis, 1998, p. 69).

Among the broad variety of theoretical frameworks in this field (Vosniadou & Ortony, 1989), we are particularly interested in analogies that are represented mathematically. For that reason, we consider the differentiation between *material* and *formal* analogy proposed by Hesse (1972). According to her, *material analogies* are taken into account when there is a physical similarity between the systems - treating a gas as a set of tiny spheres for example - whereas *formal analogies* occur when the same axiomatic and deductive relations associate both subjects and objects of similar systems, without the necessity of a material similarity between them - e.g., a RLC circuit and a spring-mass system. In this last example two considerably different physical phenomena are represented by the same differential equation and, by focusing on correspondent terms, it is possible to make promising associations such as considering the inductance as the “mass” of the circuit. The distinction between these two types of analogies is not trivial, but Hesse stresses that although two systems may have only formal analogy, the contrary does not seem to be possible since “if there is material analogy, there is presumably some structural similarity that could - at least in principle - be formalized” (Hesse, 1972, p. 355).

Raising attention to the role of formal analogies in physics, Pask (2003) states that “many powerful analogies are those in which the mathematical description component is central” (Pask, 2003, p. 526). As a historical example the author holds that the wave theory success is related to the fact that “Fresnel expressed the analogy between light and other waves in mathematical form and so overcame the mechanism difficulties involved” (p. 529). When it comes to analyzing more recent theories of the contemporary physics, the role of formal analogies becomes even more fundamental. According to Steiner (1998), the only alternative scientists found to overcome the human incapability of reasoning about objects out of our daily life and arrive at the subatomic laws of nature was mathematical analogy. Through an extensive analysis of the cardinal discoveries of contemporary physics, the author emphasizes the methodological change that took place in the last century due to the physicists’ use of *Pythagorean analogies* - “the ones inexpressible in any other language other than pure mathematics” (Steiner, 1998, p. 3). In fact, the unifying character of formal analogies is one of Feynman’s arguments to justify why, despite the enormous amount of information acquired since the beginning of scientific progress, it is actually possible for a physicist to retain a considerably broad knowledge of the physical world:

> *The equations for many different physical situations have exactly the same appearance*. Of course, the symbols may be different but the mathematical form of the equations is the same. This means that having studied one subject, we immediately have a great deal of direct and precise knowledge about the solutions of the equations of another (Feynman, 1964, p. 12-1).

ANALOGICAL REASONING IN PHYSICS EDUCATION

Due to the outlined indispensable role of formal analogies in physics, we strongly believe that they should be approached in physics education. However, one must be aware of the complexity of the theme, since perceiving analogies frequently demands a more expert-like relation to the physical knowledge. In this sense, it is not easy to envisage this approach in secondary school level. Perhaps a promising strategy is to encourage students to think about the reasons for the similarities in some physical formulas they learn. Let us consider the following three equations: $x = x_o + vt$, $v = v_o + at$ and $p_2 = p_1 + \rho gh$. It should not be difficult to bring to light the unifying mathematical structure (final = initial + variation) common to all three equations.

An interesting proposal designed for high-school, which is grounded in formal analogies, is the Karlsruhe Physics Course (Herrmann, 2000). Adopting the intuitive “substance model”, in which substance-like quantities have their balance governed by the differential equation $dX/dt = I_X + \Sigma_X$ (where X is the amount of substance, I_X is a current intensity of X and Σ_X is the production rate of X), this framework enables the establishment of associations between different physical extensive quantities, like electric charge, momentum, entropy and amount of substance. Arguing in favor of a meaningful unified approach to science teaching, the author stresses that “when using the extensive quantities as a basis for structuring the course, one can take advantage of a far-reaching analogy between the various parts of physics" (Herrmann, 2000, p. 52).

STUDY DESIGN: SEARCHING FOR "HIDDEN SIMILARITIES"

Aiming at approaching this theme in physics education, we have conducted a study that involved planning a lecture, designing a questionnaire and conducting semi-structured interviews with the goal of discussing the role of formal analogies with pre-service physics teacher students from the University of São Paulo in Brazil. The questionnaire was designed to encourage them to think about some "coincidences" in well-known physical formulas and demand reasonable explanations. We are mainly interested at the following questions: i) Are the students' capable of recognizing formal analogies? ii) How can the level of this recognition be categorized?

The 4-hour lecture was divided into two parts: the first two hours were dedicated to the discussion of an introductory text (Karam, 2007) on the role of mathematics in physics in which some historical examples and implications for education are presented. Afterwards, the 24 students answered the questionnaire and a final group discussion was coordinated by the lecturer.

In this work we present and describe the analysis of the following question: *Consider the equations $y = gt^2/2$, $K = mv^2/2$, $U_e = kx^2/2$ and $W = CV^2/2$. Comparing their mathematical structure, try to give reasons for the formal similarity between them. Is it possible to establish some correspondence between their terms? Stress not only similarities, but also differences.* This question was part of the questionnaire and was more deeply approached during the semi-structured interviews with four students.

RESULTS: QUALITY OF ANALOGY PERCEPTION

There are several possibilities of establishing analogical relations between the four equations given by the task, from the simple recognition of the integral of a linear relation until the unifying concepts of energy and work. The greater the number of associations perceived the better the quality of the analogy perception. The following table summarizes some possibilities.

	$y = \frac{gt^2}{2}$	$K = \frac{mv^2}{2}$	$U_e = \frac{kx^2}{2}$	$W = \frac{CV^2}{2}$
Constants	g	m	k	C
Linear relations	$v = gt$	$\boldsymbol{P} = m\boldsymbol{v}$	$\boldsymbol{F} = -k\boldsymbol{x}$	$Q = CV$
Infinitesimals	$dy = vdt$	$\boldsymbol{F}d\boldsymbol{x} = \boldsymbol{v}d(m\boldsymbol{v})$	$dU = -\boldsymbol{F}\mathrm{d}x$	$dq = CdV$
Integral $\int_0^x x dx = \frac{x^2}{2}$	$y = \int_0^t gt\, dt$	$K = \int_0^v \boldsymbol{v}.\,d(m\boldsymbol{v})$	$U_e = -\int_0^x -k\boldsymbol{x}\, d\boldsymbol{x}$	$W = \int_0^Q \frac{q}{C} dq$
Work of a force		Moving force	Elastic force	Electric force
Conservative field	Gravitational field		"Elastic" field	Electric field

Table 1: Possible associations between the four equations.

The 24 students who participated in our study performed rather badly on the analogy perception task. The analysis of their answers to the questionnaire, as well as semi-structured interviews conducted with four students, led us to the identification of four levels of analogy perception, which are described and exemplified in the following:

Level I – Superficial recognition of evident similarities (79.2%)

- Superficial similarities are recognized, but **neither physical justifications nor formal deductions are given**.
- Analyzed task: students only notice that all formulas consist of a constant multiplied by a squared variable.
- Transcripts: *"because in all cases we have a constant divided by two and a squared variable"; "the mathematical structure of the equations is similar. All of them have the general form* $y = a.x^2$ *and can be represented by a parabola"*.

Level II – Focus on formal deductions – lack of physical concepts (12.5%)

- The justification is based on formal arguments and mathematical deductions. However, **no physical unifying concept is mentioned** and the physical understanding of the mathematical formalism is deficient.
- Analyzed task: students mention that all formulas come from the integral of a linear function, but don't make correlations with physical concepts like energy, work or field.
- Transcript: *"All formulas can be derived from the integral over the independent variable. E.g.* $y = \int gTdT$*."*

Level III – Focus on physical concepts – lack of formal deductions (Questionnaire: 8.3%)

- Physical concepts are mentioned, qualitative explanations for the similarities are given, but no **mathematical deduction is given**.
- Analyzed task: students mention the relation of some formulas with the physical concepts like energy, work or field, but don't recognize deeper formal similarities.
- Transcript: *"In order to obtain these equations it is necessary to evoke the physical concepts of work and energy. Since these concepts are mathematically represented in similar ways, the equations have the same mathematical structure"*.

Level IV – Coherent combination of physical concepts and formal deductions

- Full comprehension of the analogy. Physical concepts are coherently connected with mathematical deductions. Physical-mathematical understanding.
- Analyzed task: students should mention the relation of some formulas with the physical concepts like energy, work or field and recognize deeper formal similarities (Table 1).
- No student was classified in this level.

CONCLUSIONS

In spite of the relevance of the subject, formal analogies are rarely systematically approached in physics education. In this sense, our preliminary results are actually not surprising. Although the students have already studied each one of these formulas separately, it is likely that they were seldom encouraged to think about these similarities and to find the unifying mathematical structure behind them. Therefore, we strongly believe that an explicit approach of the role of formal analogies with the pre-service physics teachers should enhance the quality of their perception of this valuable reasoning for physics.

Following Feynman's citation, reasoning by formal analogies is an essential physical trait and therefore should be part of the physics teacher training curriculum. Additionally, we believe that it can facilitate students' awareness of the structural role of mathematics in physical thought (Uhden, Karam, Pietrocola & Pospiech, 2011). Thus, it is also related to the introduction of Nature of Science (NOS) discussions in science teachers training courses, which has been widely recommended by the literature (Abd-El-Khalick & Lederman, 2000).

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ASSESSMENT OF STUDENTS' CONCEPTS OF MODELS AND MODELING: EMPIRICAL EVALUATION OF A MODEL OF MODEL COMPETENCE

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Abstract: Models and the modeling process are important both for scientific inquiry and communication as well as for teaching science. Several studies have described different perspectives of thinking about models. Often, different levels of understanding are either assumed or developed empirically. These levels either can be general, without differences between various perspectives, or they can be specific due to the different perspectives. This means that there are differences in the level of understanding between distinct perspectives. In the present article, a theoretical structure of the understanding and handling of models is presented which is called the model of model competence. In this structure, five perspectives are described, each with three levels with an increasing rate of understanding. Forced choice-tasks were used to assess the students' understanding of models and modeling according to the model of model competence (N = 1,180, aged 13-16). The data was used to address the issue of levels of understanding and handling models. The results indicate that there are no general levels of understanding models and modeling but five distinct perspectives.

Keywords: models and modeling, level of understanding, forced choice-tasks

INTRODUCTION

The importance of models and the modeling practice for scientific inquiry has been well described. For example, models support the development of scientific theories, they allow for the description and interpretation of data and they are promoting creative insight and imagination (cf. Frigg & Hartmann, 2006). Therefore, models are seen as "effective pedagogical tools" (Halloun, 2007, p. 653) for teaching scientific literacy. Because of these advantages, Harrison and Treagust (2000) point out that models are central for teaching and learning science.

The facilitation of a competent understanding and handling of models needs an elaboration of the perspectives that are related to the understanding of models and modeling. Due to diagnostic reasons, it is helpful to describe levels with an increasing grade of competence, too (cf. Hartig, Klieme, & Leutner, 2008). However, it is not clearly investigated whether such levels should be seen as general or as specific to the respective perspectives (cf. Grosslight, Unger, Jay, & Smith, 1991; Justi & Gilbert, 2003; Crawford & Cullin, 2005; Terzer, Krell, Krüger, & Upmeier zu Belzen 2011). In the following, the levels are called *general* when the level of understanding is equal in all perspectives. In this case, there is an understanding of models and modeling "as a whole" (Grosslight et al., 1991, p. 817) and the perspectives are not empirically distinguishable. If the level of understanding differs across distinct perspectives, it can be called *specific* (to the perspectives). In the present article, a theoretical structure of the understanding and handling of models developed by Upmeier zu Belzen and Krüger (2010) is presented which is called the model of model competence. In this structure, five perspectives are described, each with three levels with an increasing rate of understanding. Forced choice-tasks were used to assess the students' understanding of models and modeling according to the model of model competence. The data was analyzed to address the issue of general levels of understanding and handling models. Talking in terms of school practice, this can be used to decide whether to reflect on different perspectives separately or to discuss models and the modeling process as a whole (cf. Justi & Gilbert, 2003).

THEORETICAL BACKGROUND

A Model of Model Competence for Biology Education

Primarily based on the studies of Grosslight et al. (1991), Justi and Gilbert (2003) as well as Crawford and Cullin (2005), Upmeier zu Belzen and Krüger (2010) worked out a theoretical structure in which two broad perspectives (dimensions) of the understanding and handling of models are described (Table 1): knowledge about models and the modeling process (modeling). Whereas the first dimension is subdivided in to the two aspects nature of models and multiple models, the second dimension entails the aspects purpose of models, testing models and changing models. Each aspect is further divided into three levels of understanding based on the concept of model described by Mahr (2009). The author underlines that the identity of something as a model depends on two "constructive relationships" (p. 371): an object is a model as long as it is a model of something (creation of the model) and a model for something (application of the model). Mahr also distinguishes between the model object which can have different modes of representation such as concrete material, visual, or verbal (cf. Boulter & Buckley, 2000) and the model which is "purely mental" (Mahr, 2009, p. 371). Thus, it is possible to understand a model only as a model object without recognizing the connection with the corresponding mental model. This concept of a model was used by Upmeier zu Belzen and Krüger (2010) to develop the three levels of understanding in the model of model competence (Table 1). However, the theoretical structure has not been evaluated empirically yet.

Table 1: A model of model competence (Upmeier zu Belzen & Krüger, 2010).

	Level 1	**Level 2**	**Level 3**
Knowledge about models			
Nature of models	Replication of the original	Idealized representation of the original	Theoretical reconstruction of the original
Multiple models	Different model objects	Different foci on the original	Different hypotheses about the original
Modeling			
Purpose of models	Describing the original	Explaining the original	Predicting something about the original
Testing models	Testing the model object	Parallelize the model and the original	Testing hypotheses about the original
Changing models	Correcting defects of the model object	Revise due to new insights	Revise due to the falsification of hypotheses about the original

Levels of Understanding Models and Modeling: General or Specific?

There are several studies in which the students' (e.g. Grosslight et al., 1991; Grünkorn, Upmeier zu Belzen, & Krüger, in press; Treagust, Chittleborough, & Mamiala, 2004) or the teachers' (e.g. Justi & Gilbert, 2003; Crawford & Cullin, 2004, 2005) understanding of models and modeling is investigated. In the following, three of these are introduced which address the levels of understanding.

One of the first studies about the understanding of models is presented by Grosslight et al. (1991). According to the authors there are mainly five different perspectives (called aspects) in the understanding of models and modeling (kinds of models, purpose of models, designing and creating models, changing models and multiple models). Furthermore, the authors were able to describe three "general levels of thinking about models" which describe the "understandings and conceptions of models […] as a whole" (p. 817). Justi and Gilbert (2003) asked teachers about models and worked out seven aspects which are similar but not identical to the ones described above: nature of models, use of models, entities of which the models are composed, uniqueness of models, stability over time, making predictions and accreditation of models. Justi and Gilbert (2003) explicitly address the question of general levels in their analysis and conclude that "data provide no support for the notion of 'level' in the teachers' understanding of the notion of 'model'" (p. 1381). In fact, most of the interviewed teachers show a complex pattern of understanding which varies across the different aspects (Justi & Gilbert, 2003). A third study which deals with levels of understanding models and modeling is presented by Crawford and Cullin (2004, 2005) who interviewed prospective teachers. The authors report five dimensions which are similar to the aspects described by Grosslight et al. (1991): purpose of models, designing and creating models, changing a model, multiple models and validating and testing models. In addition, the authors assumed four general levels of understanding: limited, pre-scientific, emerging scientific and scientific. Although Crawford and Cullin (2005) were able to report a shift in the teachers' understanding, their subjects "tenaciously held on to some scientifically uninformed views" (p. 318).

In sum, these studies give an ambiguous answer to the question whether there are general levels in the understanding of models and modeling or not. Whereas Grosslight et al. (1991) report general levels, both Justi and Gilbert (2003) and Crawford and Cullin (2004, 2005) are not able to identify general levels of understanding across the different aspects. In other words, it is not clearly investigated whether there is an understanding of models and modeling as a whole or if the level of understanding varies between different distinct perspectives. The present article addresses this issue related to a theoretically developed structure of understanding and handling models which is called the model of model competence (Table 1).

RESEARCH QUESTION AND HYPOTHESES

The research question of the study is related to the empirical evaluation of the model of model competence: In what sense are the three levels of understanding general or specific to the respective aspect? Three alternative hypotheses (H1, H2, H3) can be deduced from the theory:

H1: The three levels are general. The level of understanding does not vary between the different aspects.

H2: The three levels are partly general. The level of understanding does not vary within the two dimensions knowledge about models and modeling but does vary between these two dimensions.

H3: The three levels are specific due to the five aspects nature of models, multiple models, purpose of models, testing models and changing models. The level of understanding varies across all these aspects.

METHODS

Data Collection

On the basis of the model of model competence, forced choice-tasks were developed (Krell & Krüger, 2010). In each task, a concrete model is presented and the respondent has to rank the three levels of the relevant aspect according to his or her own understanding of the shown model. The ranking options were generated deductively and are therefore rather abstract and close to the theory (e.g.: *the model looks like the original*). This is why the forced choice-tasks are assessing what Treagust et al. (2004) call a "theoretical understanding" (p. 16) of models and modeling. In the present study, six tasks for each aspect of the model of model competence (30 tasks in total) were used to investigate the students' understanding of models and modeling. A multi-matrix-booklet-design was conceptualized to keep the number of tasks for every single student small. The sample consists of 1,180 students at the age of 13-16, currently attending public schools (Gymnasium) in Berlin, Germany.

Data Analysis

The data was analyzed using the partial credit-model, a Rasch model which allows for partial scoring (cf. Yen & Fitzpatrick, 2006). In order to test whether the theoretically described levels are general (H1) or specific in terms of dimensions (H2) or aspects (H3), three different measurement models were specified and evaluated in the software ConQuest (Wu, Adams, & Wilson, 2007).

H1: The one-dimensional (1D) measurement model does not differentiate between the tasks of the five theoretical aspects and therefore postulates three general levels of understanding and handling models.

H2: The two-dimensional (2D) measurement model subsumes the tasks of the aspects nature of models and multiple models on the one hand and the aspects purpose of, testing and changing models on the other hand.

H3: The five-dimensional (5D) measurement model was analyzed which postulates the independence of the five aspects (but allows correlations between them).

The three measurement models are nested models (cf. Schermelleh-Engel, Moosbrugger, & Müller, 2003) which deduce directly from the structure of the model of model competence ("choose the model first"; Yen & Fitzpatrick, 2006, p. 124) and which are operationalizations of the three hypotheses H1, H2, H3 formulated above. In order to evaluate the goodness of the measurement models, two information indices were computed: the cAIC and the ssaBIC which are variant forms of the AIC and the BIC. Unlike the AIC, the cAIC takes the sample size into account and the ssaBIC does not overemphasize the parsimony of the measurement model as strong as the BIC (cf. Burnham & Anderson, 2004). The cAIC and the ssaBIC can be used to compare the goodness of different measurement models. When doing this, the smallest value of each index indicates the relatively best fitting model (cf. Kang, Cohen, & Sung, 2009). To test whether the differences between the fit of nested measurement models are significant, one can additionally perform a chi square difference test (cf. Schermelleh-Engel et al., 2003).

FINDINGS

Table 2 shows the information indices for the three measurement models. The results show that in both cases the 5D measurement model describes the data (relatively) best. The chi square difference test shows that the differences between the fit of the three measurement models are significant (Table 3). This is an additional argument for the 5D measurement model. If the differences had not been significant, one should have preferred the most parsimonious model which is the 1D model in the present case (cf. Collins & Lanza, 2010).

Table 2: The values of the cAIC and the ssaBIC for the three measurement models (1D, 2D, 5D).

	cAIC	ssaBIC
1D	13,355.56	13,426.29
2D	13,325.86	13,392.15
5D	13,288.41	13,327.70

Table 3: Results of the chi square difference test. The value of the chi square (x^2), the number of the degrees of freedom (df) and the significance (sig.) are shown.

	x^2	df	sig.
2D - 1D	34.14	2	< 0.001
5D - 2D	64.45	12	< 0.001
5D - 1D	98.59	14	< 0.001

Using the 5D measurement model, fit statistics for the single tasks were computed. The wMNSQ for the overall item parameter is 0.95-1.07, whereas the wMNSQ for the step parameter is 0.88-1.08. Both values indicate a good fit between the tasks and the 5D partial credit measurement model (cf. Bond & Fox, 2001). The findings reported here are in line with the results of a preliminary study with a smaller sample of 901 students (Krell & Krüger, submitted).

DISCUSSION

The findings show that the 5D measurement model describes the data best. In other words, the students' understanding of models and modeling varies between five distinct aspects. For example, the understanding of the aspect purpose of models may be less elaborated than of the aspect testing models (and vice versa). Justi and Gilbert (2003) reported similar results on the basis of their theoretical assumptions. The authors concluded that their interviewees "do not hold coherent ontological and epistemological views" (p. 1382). According to the model of model competence (Table 1), the theoretically described levels do not seem to be general, too. In this sense, the current outcomes are similar to the results reported by Crawford and Cullin (2005) because the authors assumed a structure with four general levels (limited, pre-scientific, emerging scientific and scientific) but were not able to describe general levels of understanding empirically. Whereas both Justi and Gilbert (2003) and Crawford and Cullin (2005) investigated the teachers' understanding, in the present study students were tested. All in all, the more recent findings (Justi & Gilbert, 2003; Crawford & Cullin, 2005; the present study) suggest not to think about the understanding of models and modeling as a whole but to differentiate between distinct aspects.

Regarding the features of the forced choice-tasks, it can be said that they measure an abstract and therefore a more theoretical understanding of models and modeling. Treagust et al. (2004) assessed the students' understanding of models in a similar way and also analyzed lessons in which the students had to handle models concretely. From their findings the authors conclude that a "theoretical understanding of the scientific model is not necessarily related to practical applications of the teaching model" (p. 16). Similarly, Terzer et al. (2011) show that the students' understanding of models and modeling is not the same when being asked on an abstract level (forced choice-tasks) and on a concrete level (multiple choice-tasks developed by Terzer). When assessing the students' concrete understanding of models and modeling, the level of understanding seems to be general (Terzer et al., 2011). The different findings of Grosslight et al. (1991) on the one hand and Justi and Gilbert (2003) as well as Crawford and Cullin (2004, 2005) on the other hand could depend on their slightly different theoretical assumptions (i.e. the different aspects/dimensions). But the forced choice-tasks and the multiple choice-tasks were both developed on the basis of the model of model competence

(Table 1). This strongly supports the findings of Treagust et al. (2004) who report differences between the students' theoretical and practical understanding of models.

PROSPECT

Talking in terms of school practice, the absence of general levels of understanding could indicate a lack in the students' understanding of scientific models and the modeling process in science because an elaborated understanding of models and modeling means to understand all aspects in a sound manner (Justi & Gilbert, 2003). Therefore, teachers should reflect on all the five aspects explicitly (cf. Justi & Gilbert, 2003; Fleige, Seegers, Upmeier zu Belzen, & Krüger, in press).

The differences between the results of the abstract and the concrete operationalizations have to be investigated further (Terzer et al., 2011). So far, the data of both kinds of operationalization have been analyzed separately. Therefore, the next step will be a common analysis of the data to work out direct correlations between the students' abstract and concrete understanding of models and modeling. Doing this, one should find out whether there is a more elaborated theoretical understanding as it is reported by Treagust et al. (2004). In addition, the model of model competence is evaluated using open ended (Grünkorn et al., in press) and hands on-tasks as well (Hänsch & Upmeier zu Belzen, 2011). Looking at the results of the forced choice-tasks in particular, further analysis will focus on the closer description of the students' theoretical understanding of models and modeling. For this purpose, a latent class-analysis (Collins & Lanza, 2010) will be conducted in order to describe several distinct patterns of understanding.

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STUDENTS' UNDERSTANDING OF THE NATURE OF SCIENCE: A LARGE SCALE TRANS-NATIONAL COMPARISON

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Abstract: A large sample of young science students from several countries has been surveyed to assess their understanding of the nature of science. Each student anonymously answered 15 questions, which involve scoring one hundred sentences that are scaled into a set of attitudinal indices. The global results show an overall neutral (grand mean score around zero) students' understanding, though the detailed examination of indices identifies many differences across countries and positive or negative profiles across issues. The diagnosis that emerges from the data is quite complex, as appropriate beliefs coexist with some inappropriate beliefs within any country. Further, each country's profile allows delineating its specific achievement in relation to nature of science understanding. The results suggest the general need to improve the quality of science teaching on nature of science issues, and especially in those countries whose profile tend to be lower than others. The implications of the methodology and the results for the research, for teaching science, and for teacher training on the nature of science and technology issues are discussed.

Keywords: nature of science, science-technology-society, evaluation of conceptions, student conceptions, trans-national comparison.

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BACKGROUND, FRAMEWORK, AND PURPOSE

Science education scholars consider today the nature of science an essential educational goal, and a basic component of the scientific and technological literacy for all, and yet an innovative element of science education, which adds some difficulty to its teaching (Millar & Osborne, 1998).

PISA (OECD, 2010) defines scientific literacy as an individual's scientific knowledge, and the use of that knowledge, to identify scientific issues, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues; their understanding of the characteristic features of science as a form of human knowledge and enquiry; their awareness of how science and technology shape our material, intellectual and cultural environments; and their willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen.

Summing up, PISA's scientific literacy is made up of knowledge "of" science and knowledge "about" science; the former is the cognitive knowledge of the features, theories and laws that rule the physical, earth and space, living, and technology systems; the latter involves the understanding of science and technology as a form of human knowledge and enquiry, their attitudinal awareness of how science and technology shape our material, intellectual and cultural environments, and their attitudinal willingness to engage, as a reflective citizen, with the ideas of science, and in science-related issues. It seems clear that PISA literacy component involves knowledge, process and attitudinal components about science and technology, designing on its own the nature of science (and technology) (hereinafter, NoS).

Since the early 70s, the empirical research shows repeatedly and consistently that the students do not have a proper understanding of NoS. The students often hold traditional, positivist (logical empiricist), and idealistic views of S&T, which are close to the list of myths on science (McComas, 1996), or contrary to the list of consensuses on NoS (Bartholomew, Osborne & Ratcliffe, 2004). They do not distinguish between science and technology and the current relationships among science, technology and society (STS), do not understand the role of the scientific method, theories and hypotheses, models, creativity and tentativeness in the validation of scientific knowledge (for instance, Lederman, 2007).

RATIONALE

The diagnostic studies of students' NoS understanding have been scarcely conducted in Latin contexts and using big research samples. This paper examines the science students' NoS beliefs from a large sample of young students, who are running their last year in high school (grade 12) or their first year in college, in the framework of an international cooperative investigation (Iberian-American Project of Evaluation of Attitudes Related to Science, Technology and Society, Spanish acronym PIEARCTS) across seven Iberian-American Spanish and Portuguese-speaking countries (Vázquez, Manassero, & Bennassar, 2009). The sample of PIEARCTS consists of several layers:

i) Young students, who begin their college or finish their high-school (17 to 19 years old),

ii) Veteran students in their last year of college, master or just graduate (22 years and older),

iii) In-service teachers of all educational levels.

The new PIEARCTS methodology allows the use of inferential statistics (ANOVAs) to hypothesis testing, for instance, to compare countries or groups of students. The research tries to answer the following questions: Which are the global strengths and weaknesses of NoS understanding of the Iberian students'? Are there differences among countries in students' NoS understanding?

METHODS

The main contribution of this paper is the presentation of a new instrument, scoring method, and quantitative methodology to assess NoS conceptions that allow implementing easy and reliable applications to large representative samples, using inferential statistics to check out differences between groups or setting up cut-off points for deepening the qualitative analyses of the quantitative data.

Sample

The participants are 4,533 young students engaged in the last high-school year or the first college year (most of them about 17 to 19 year-old) and have already made a choice for school science. The sample approximately splits in equal halves by sex (53% men) and by the two questionnaire forms (1 or 2) that answered each student (Form 1, 52%).

Instrument

The participants' NoS conceptions are assessed through a paper and pencil multiple-choice items, which allow easy and reliable applications to large representative samples, due to a new methodology and model design. Each item poses an issue, using a common and simple non-technical language style; a variable number of sentences, each labelled with a letter A, B, C…, follow the stem text. Each sentence states a particular reason that explains a position (belief) on the stem issue. Each item is identified by a five-digit number: the first digit signifies the dimension, and the remaining digits represent themes and sub themes; the five digits plus a letter identifies the items' sentence variables (Vázquez, Manassero & Acevedo, 2006).

The PIEARCTS research team consensually selected 30 items that are allocated into two 15-item paper and pencil research booklets (F1 and F2) from the Questionnaire of Opinions on Science, Technology and Society (Spanish acronym, COCTS). The COCTS is an adaptation into Spanish language and culture of the VOSTS and TBA-STS empirically developed items (Aikenhead & Ryan, 1992; Rubba, Schoneweg & Harkness, 1996), which form a pool of 100 multiple-choice items that inherits the credit of VOSTS and TBA-STS, as one of the best paper and pencil instruments to evaluate NoS&T beliefs (the empirical development of items warrants the item validity). The 30 items contain 200 sentences and cover the dimensions displayed in table 1.

Table 1. Dimensions of the general structure of the issues and labels of the 30 questions included in the two questionnaire forms (Form 1 and Form 2). Note the correspondence between each dimension and the first number of the question label; a short description of the question content (sub themes) follows each key number.

Dimensions	Form 1 Items (key / issue)	Form 2 Items (key / issue)
a) Definition of S&T	F1_10111 science	F2_10211 technology
	F1_10411 interdependence	F2_10421 interdependence quality of life
b) STS Interactions	F1_30111 STS interaction	
Influence of society in S&T	F1_20141 country's government policies	F2_20211 industry
	F1_20411 ethics	F2_20511 educational institutions
Influence of S&T in society	F1_40161 social responsibility contamination	F2_40131 social responsibility information
	F1_40221 moral decisions	F2_40211 social decisions
	F1_40531 life welfare	F2_40421 Application to daily life
		F2_50111 union two cultures
Internal Sociology of science	F1_60111 motivations	F2_60521 gender equity
	F1_60611 women under representation	F2_70211 scientific decisions
	F1_70231 consensus decisions	F2_70711 national influences
	F1_80131 advantages for society	
c) Epistemology	F1_90211 scientific models	F2_90111 observations
	F1_90411 tentativeness	F2_90311 classification schemes
	F1_90621 scientific method	F2_90521 role of assumptions
		F2_91011 epistemological status

Procedures

The respondents rate their agreement (1, total disagreement; 9, total agreement) on each item sentence. These scores are scaled into quantitative indices (-1, +1), whose meaning is invariant across all sentences: the higher (lower) the index score, the higher (lower) the respondent's opinion fitness with the current knowledge from history, philosophy and sociology of S&T (Vázquez & Manassero, 1999; Vázquez et al. 2006). Averaging the sentence indices within each item, four new indices are produced: three indices for the three groups of sentences (categories) and one global index for the whole item. Thus, this scheme describes the student's thinking on NoS through over one hundred and fifty invariant indices (sentence, category and item indices).

The indices allow the use of inferential statistics for hypothesis testing, which can be applied to compare countries or groups, or to set up cutting points for identifying the strengths (highest positive), weaknesses (lowest negative), and neutral beliefs (Vázquez, Manassero & Acevedo, 2006). The criteria to achieve relevance are the statistical significance ($p < .001$), and the effect size, or the differences expressed in standard deviation units ($d > .30$).

RESULTS

The results are expressed through the global item index (weighted average of the sentences through categories) for the 30 applied items in the two booklet forms; the results are analyzed according to the different places (two countries contribute with two places each) where the instruments were applied (each labelled by a letter and a number to preserve confidentiality).

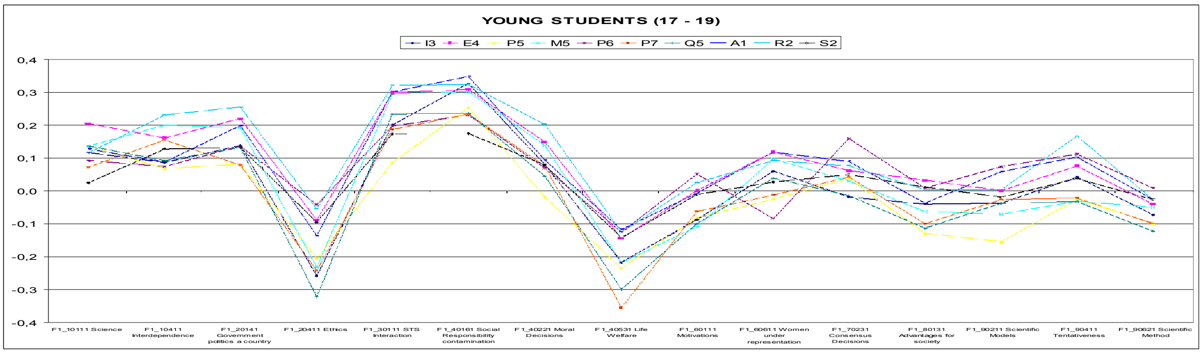

Figure 1. Overall mean results for the 15 items of F1 booklet items across all the places.

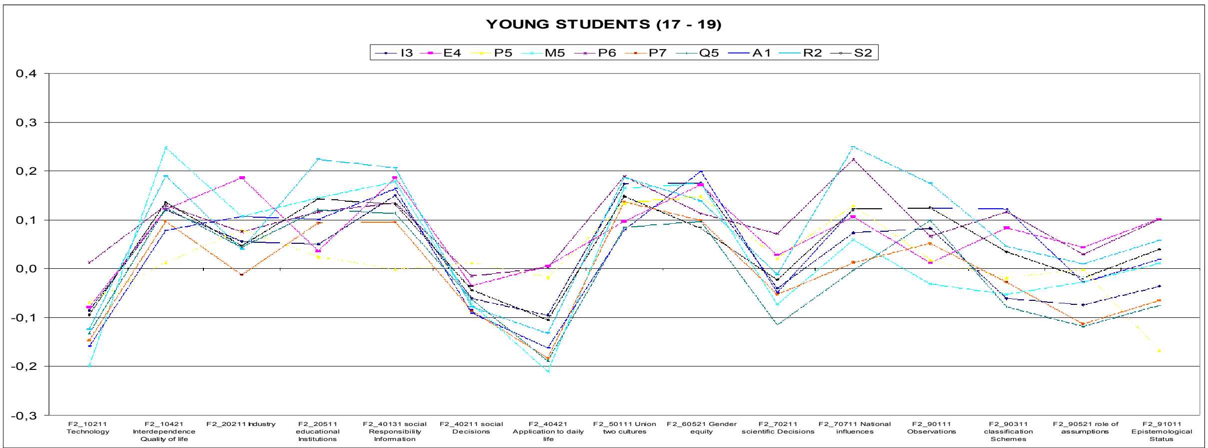

Figure 2. Overall mean results for the 15 items of F2 booklet items across all the places.

Overall, the results show a broad similar evolution across items for the different places; thus, the highest positive (strengths) or lowest negative (weaknesses) scores for the issues are approximately the same for all places. They are selected by the relevant effect size criterion: mean indices higher or lower than one third of a mean standard deviation with respect to the overall mean of the place, though the differences between countries in some items is so high that the strengths and weaknesses are selected on the global average.

The sorted list of F1 and F2 items, which represent students' strengths, is the following: F1_30111 STS Interaction, F1_40161 Social Responsibility contamination, F2_50111 Union two cultures (lower than those of F1), and F2_60521 Gender equity (lower than those of F1).

The list of items, which represent students' weaknesses, is the following: F1_20411 Ethics F1_40531 Life Welfare, F2_10211 Technology, and F2_40421 Application to daily life.

The second feature showed in the figures are some marked differences in NoS understanding between countries and sites, as some sites are getting better and worst achievements than others, and some items display big differences among sites. For instance, sites A1, R2 and E4 display overall top averages along the items, while sites S2 and P7 have got bottom averages.

Further, many items set up big differences among sites, as most of the items exhibit differences greater than .10 (d > .30) between their top and bottom sites, although these relevant differences display somewhat different homogeneity among sites. Just three items exhibit the lowest differences among the sites, which hardly get the relevance criterion (d > .30): F2_40131 social responsibility information, F2_50111 union two cultures, and F2_60521 gender equity.

Obviously, as PISA rules for science achievement, the noticeable differences in NoS understanding among sites suggest the potential relationships between NoS and the school science curriculum design and implementation, or concerns about the effective presence, treatment, and teaching implementation of NoS issues.

The methodology allows the application of inferential statistics in hypothesis testing, which is applied here to compare the NoS beliefs of young students of E4 site against veteran students and in-service teachers. The overall differences among the three groups are not statistically significant, although a noticeable trend is that young students display poorer NoS understanding (lower scores) than the other two groups (veteran and in-service teachers), which exhibit a quite remarkable equality between them (figures1 and 2).

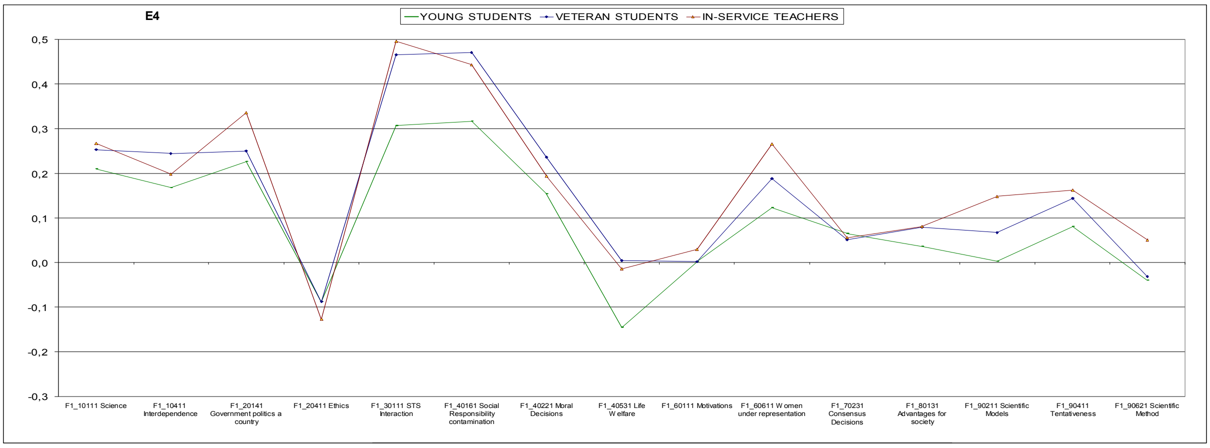

Figure 1. Comparison among young students, veteran students and in-service teachers of the E4 site for the 15 items of F1 booklet items.

When testing the differences among groups along the 30 issues of the two forms, the general trend exhibit some additional nuances, as a few items present significant differences of the young students in relation to the other groups, which means young students score significantly under the other two groups. In F1, the inferiority of the young students in relation to other groups is significant for the item issues F1_30111 STS interaction, F1_40161 social

responsibility on pollution, F1_40531Welfare and standard of living. In F2, young students have scores significantly below the other groups on issues F2_10421 Interdependence, Quality of life, F2_20511 educational institutions, F2_50111 Union of two cultures and F2_90521 true assumptions.
In contrast, the testing of differences also uncovers two issues (F2_40421 Resolution in your daily life and F2_90111 Observations) that attract attention because they provide a counterpoint to the previous dominant trend: young students show higher scores than the other groups, and the differences are relevant for the group of young students.

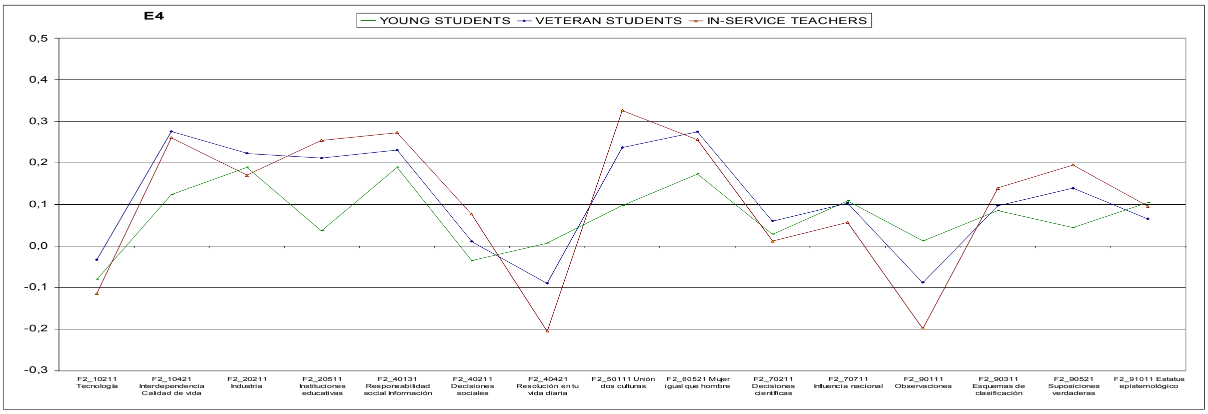

Figure 2. Comparison among young students, veteran students and in-service teachers of the E4 site for the 15 items of F2 booklet items.

CONCLUSIONS AND IMPLICATIONS

The instrument and methodology presented here allows cheap, quick and easy assessments of the NoS, a quality that is specially appreciated for applications to large samples, as is the case presented in this paper. Moreover, the assessment instrument and method fit the requirements recently suggested by Allchin (2011) for appropriately assessing functional NoS understanding: authentic context, well-informed analysis, adaptability to diagnostic, formative or summative evaluation, adaptability to single, mass, local or large-scale comparative use and the respect for relevant stakeholders. Further, the research project PIEARCTS is an example of large-scale applications across seven countries and involving over 16,000 valid answers (Bennássar-Roig, Vázquez-Alonso, Manassero-Mas, García-Carmona, 2010; Manassero et al., 2010).

On the basis of the quantitative use of indices, the study identifies some qualitative features, such as strengthens (conceptions that fit the experts' current knowledge) and weaknesses (conceptions that oppose the experts' current knowledge) on NoS understanding of young students.

The lack of deep differences between young students, veteran students, and in-service teachers, when higher scores would have been expected for science teachers, is a disappointing result, as it points the overall lack of attention to NoS issues in science education. First, the lack of big differences between young and veteran students points out to the relative inefficacy of higher education graduate science programs to adequately teaching NoS. Second, the absence of differences between science veteran students and in-service teachers points out to the inefficacy of teacher pre-service and in-service training to prepare teachers on NoS. Thus, science curriculum design and implementation, and science teacher training have to be redesigned so that the teachers and students' understanding of NoS could be improved.

Most of these strengths and weaknesses are widely shared across countries and the different groups surveyed through the questionnaires (Bennássar-Roig, et al., 2010). As PISA does for science achievement, this study also evidence differences in NoS understanding among countries, which refer back to the development of science education in each country (contents in school curricula, teacher training, practices of teaching, etc.). In fact, the results might be used to highlight national strengths and weaknesses, and develop programs to improve NoS teaching and NoS learning.

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THE NATURE OF SCIENCE IN PHYSICS COURSES: PLACE AND ROLE OF THE HISTORY OF SCIENCE

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Abstract: Physics and chemistry programs at the secondary school level in France recommend introducing components of the history of science. Emphasis is placed on a "cultural" dimension, which is poorly defined but essentially refers to elements of epistemological nature. But there is no connection between this implicit epistemological aim of science education and the learning goals specified for each thematic domain: they only concern the scientific concepts and process. Our main issue is to examine the possibility to communicate a more authentic image of the nature of science with the introduction of the history of science. We begin by demonstrating how our historical and epistemological analysis of physics led us to distinguish different aspects of scientific activity that may constitute key points for a didactical transposition and can be chosen as different learning goals. We then show how these goals (e.g. "interactions between scientists" or "science-technology relationships") can generate kits of texts and activities for students that are both appropriate to a given level of instruction and fulfil such a specific epistemological objective. Our innovative approach is based on the nature of investigative situations (with experiments or not): the reading assignment is divided among all students and the synthesis consists in collectively drawing a diagram providing a synoptic visualization of the epistemological objective. Finally we discuss the tensions that our choices created among teachers.

Keywords: nature of science, history of science, secondary level teaching, innovative pedagogical units, teachers

INTRODUCTION

The issue of the nature of science (NoS) is more suggested than explicitly stated in the French science programs at the secondary school level. It may be extrapolated from their introductive components that recommend introducing *an historical perspective*. Emphasis is placed on a "cultural" dimension, which is poorly defined but essentially refers to elements of epistemological nature. But there is no connection between this implicit epistemological issue of science education and the learning goals specified for each thematic domain: they only concern the scientific concepts and process. Moreover, the programs suggest very few examples of activities based on the history of science (HS): most of them are means to learn scientific content and convey a reductive and false image of science. This is the same case for the science textbooks (Beaufils & Maurines, 2008; Guedj, Laubé, & Savaton, 2007). Their historical elements refer to only one person who is most often well known. Discoveries seem to happen immediately and are linked to a specific date; they appear to be animated by a superhuman mind possessed with intuitive genius, arising from an unequivocal idea or a decisive experiment. Besides, many teachers share an outmoded vision of the sciences (empirically inductive and naïvely realistic) and unconsciously convey this stance to their students through the way they teach. Moreover, they are unaware of the epistemological issue of science learning (Robardet & Vérin, 1998; Pélissier, Venturini, & Calmettes, 2007).

This situation, close to the one described abroad by many science education researchers (Höttecke & Silva, 2011; Larochelle & Désautels, 1992; Lederman, 2007; Matthews, 2003; Mathy, 1997) working on NoS led us to begin a research program that examines whether the introduction of HS[1] in teaching can help to address the epistemological issue of scientific education. Our position is unique in France. Almost all other recent work concerned with the use of HS in physics courses (Décamp & de Hosson, 2010; de Hosson & Kaminski, 2007; Guedj, 2005) does not explore this aspect but focuses on the acquisition of scientific concepts; the historical elements introduced in most of these different studies concern controversies over the interpretation of specific phenomena and are minimalized.

The underlying stake of our research is that historical resources and student-centered activities, which offer a heightened sense of the reality of NoS, can provide a broader scientific cultural integration for students and have a positive effect on their relationship with science as an academic discipline. This is a significant societal issue, given students' current disaffection with the branches of basic science. We confer with Solbes and Traver (2003) on that point. Moreover, following Driver, Leach, Millar and Scott (1996), we also believe that the acquisition of a scientific and cultural background allow students to become responsible citizens, capable of understanding and taking action in a world where science and technology occupy a predominant place.

RESEARCH QUESTIONS AND METHODOLOGY

The issue of greater authenticity in representing NoS in physics classes has several main aspects. First, how do we characterize this authenticity and which approach do we choose in order to address the cultural and democratic rationales for including NoS in science teaching? Second, what pedagogical goals can be pursued and can historical examples be found that are compatible with science programs and students' academic level? If so, what historical resources and activities support these objectives and how are they integrated in the traditional teaching focused on science content? Third, how teachers judge these innovative proposals and put them into practice? The area of specialization of our team members led us to explore these questions in the case of physics.

Our work initially consisted of complementary analyses concerning the nature of science and scientific activity, the high school programs, the science textbooks, the students' and teachers' epistemological conceptions and teachers' practices. They led us to 1) discern different characteristics of scientific activity and knowledge that may constitute key points of an authentic image of science upon which didactic goals may be based *a priori* ; 2) identify "historical situations" (e.g. the interpretation of the law of refraction) that could be integrated into physics' curricula. We then created and designed didactic resources and activities for students that were both appropriate to a given level of instruction and fulfilled a specific epistemological objective. Before spreading our pedagogical propositions, we sought to improve them in taking into account teachers' feed-back. We contacted various colleagues who had replied to a first inquiry on their relationship to the use of the history of science in teaching (Beaufils, Maurines, & Chapuis, 2010) and expressed interest in receiving complete pedagogical resources. The information returned to us completed the first synthesis of material that resulted from a session of ongoing teacher training (January 2009). Some results of this stage of our research are given in the last section of this paper.

DESIGN OF INNOVATIVE PEDAGOGICAL UNITS

Epistemological learning goals

In our project, HS is not considered *per se* but as a means to introduce students to 20th century philosophical ideas on science[2]. This is a richer understanding of how science works mainly today, and not in the past, that we expect. Consequently, we sought to identify through the analysis of the history of physics what aspects of physics can be considered as temporal invariables[3]. Since the intersection of the various studies of science is where the most authentic view of science is revealed, we based our analysis on the philosophy, history, psychology and sociology of science[4]. This approach led us to the "consensus view" of the nature of science which comprises a set of aspects widely accepted in standard documents (Project 2061 for example) and philosophy of science (Lederman, 2007).

In our opinion, introducing the history of science highlights episodes of scientific activity of various lengths seen through a series of critical filters relative to the NoS such as show that 1) scientific activity is a nexus of controversy; 2) scientific knowledge follows criteria of internal coherence, simplicity, and strength and has to be confronted with facts based on observation and experiments; 3) a scientist does not work in isolation but within a community that participates in testing established scientific knowledge; 4) there is a relationship between technical questions and the evolution of ideas; 5) etc. We would like to observe first of all that since these goals focus on epistemological aspects, they are independent of conceptual or procedural learning objectives, which therefore can be only secondary, if not completely absent. This position is close to the one presented by Lederman and Abd-El-Khalick (1998) about activities relating to the nature of science.

Historical resources for students and historical investigative situations

Several didactic choices determined the direction of our pedagogical research: elaborating resources and suggesting activities for students beyond simply providing documentary resources for teachers, offering collective activities to students that permit complementary or contradictory interactions, the development of common, shared knowledge, etc. In other words, the choice reflected our attempt to integrate the resource kits with investigative situations which pair texts with experiments or not. With a view to suggesting a wide variety of activities to teachers and pupils, we have developed resource kits based on short documents, designed according to the stated goal. The documents present information in different forms—texts, diagrams, drawings, etc.—which is usually taken from texts written by historians or scientists keen on history but also from primary sources or which we can have written. Our primary objective is to propose students with texts easily to read.

Historical experimental investigative situations

In some of our first proposals (Maurines and Mayrargue, 2005, 2007), the reading of historical texts is coupled with doing an experiment described or inspired by the texts, thereby following the hypothesis that some teachers prefer situations that link texts with experiments, since they might not want to deviate from their preferred conceptual or procedural learning goals. This approach becomes most meaningful when the targeted goal stresses the process of validating a model by confronting its prediction with facts derived from observation or/ and experimentation (e.g. in insert 1). The choice seems artificial, however, and therefore inappropriate in relation to a goal like studying "interactions between scientists." In this type of situation, the risk of drifting off course toward an emphasis on knowledge and methods is especially high. It is fundamentally important to explicit the epistemological dimension during the last phase of the teaching situation. Höttecke et al (2010) whose approach is close to the one proposed here suggest to arrange furniture in the classroom in order to create an "epistemological corner", i.e. a place dedicated to the reflection on the nature of science.

Insert 1: A possible structural outline of an activity combining texts and experiments (Topic: the dispersion of white light through a prism)

Appropriating or/and constructing a problem
- create a conflict by reading texts: compare de Dominis' and Newton's models.
- state hypotheses inspired by the texts: Is white light homogeneous and are colors created uniquely by the action of the prism?

Resolving of the problem
- develop experiments that allow the hypothesis to be tested, revealing its consequences.
- confront expectations with the results of the experiment
- invalidate the model of homogeneous white light

Establishing knowledge
- **scientists test their explanations against facts that result from observation and experiments; they valorize those explanations that allow for a large number of facts to be interpreted simply**.
- white light is heterogeneous and composed of colored light

Historical documentary investigative situations and synthesis diagrams

More recent proposals (Maurines, Beaufils, & Chapuis, 2009) are based on the collective analysis of resource kits designed to examine a specific characteristic of scientific activity: the interactions between scientists, the relationships between technical questions and the evolution of ideas, for instance. Insert 2 presents a possible structural outline of such documentary investigative situation.

Insert 2: A possible structural outline of an investigative situation based on texts

Appropriating or/and constructing a NoS problem:
- integrate the topic into the teacher's learning sequence for the class; highlight questions of a historical nature: *how do we know that...?*
- specify a specific problematic that sets the goal to be achieved

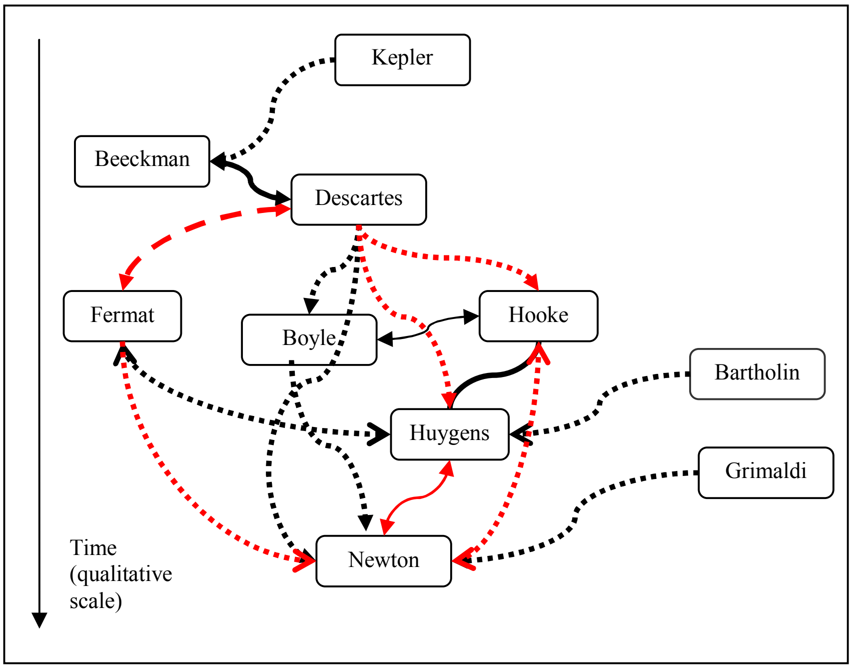
Resolving the problem :
1) Documentary work (as homework or in class, individual or in small groups)
- present documentary resources.
- distribute the documents among the members of the class
- read documents and prepare the lesson in which the synthesis will be done, guided by instructions that specify the type of information to be culled from the text; who, what, how, why, etc. (in relation to the documents and the question).

2) Reaching a synthesis (students will do this collectively based on each class member's contribution)

Establishing knowledge:
- **the teacher generalizes the results that were found by students and shows the connection between how science worked in the past and the present situation**.

The kits are usually composed of about ten interrelated documents, characterized by a "point of entry" directly related to the goal to be achieved: this might take the form of scientists' names, for instance, or technical achievements. Contrary to the stories proposed by Clough (2010), each document gives only some information. The reading assignment of the kit is divided among all members of the class and the collective synthesis is made under the teacher's "guidance". Thus, enough information can be provided to students in order to convey a more realistic image of NoS without discouraging poor readers and requiring too much time. The synthesis that is made in class is supposed to produce a specific type of result: a diagram that provides a synoptic visualization of the information that has been gathered and illustrates the targeted goal. Insert 3 presents an example of such diagram that students could produce. As far as we know, this collective strategy and type of synthesis activity have never been proposed by science educators contrary to the previous one which pairs texts with experiments (Höttecke, Henke, & Riess, 2010).

Insert 3: Example of diagram on the epistemological objective "interactions between scientists" and the topic "laws of refraction"[5]



BY WAY OF CONCLUSION: SOME REMARKS ON THE FIRST FEED-BACKS OBTAINED FROM TEACHERS

The majority of responses given by the sixteenth teachers who answered the questionnaire on the feasibility of our proposal on the topic of refraction and on the epistemological goal "interaction between scientists" indicated that the objective was interesting, stressing the fact that the evolution of science, with its complexity and social dimension, should be demonstrated. Responses were largely positive in favor of presenting this kit at the grade 10 level but some colleagues' expressed reserve and were concerned that the intellectual level of the students would be overly challenged by documentary activities involving reading that was beyond their critical ability. The answers to the questions on the pedagogical organization range from positive feed-back arguing for a simple activity that could be integrated into the complete set of activities students are asked to perform, to negative feed-back, arguing that the texts were too difficult, that the synthesis students were asked to make (a diagram) was too abstract, and that the context was too exclusively cultural, independent of notional learning, requiring highly motivated students. They also argue that they are not trained on the NoS. All this send back to a curriculum issue (conception of science programs and aims which are assigned to them) but also to an issue centred on the teachers (their training and their conception of science teaching, and more fundamentally, of science).

NOTES

[1] Other proposals can be found in Maurines (2010).
[2] Our approach is similar to Aduriz-Bravo's one (2010).
[3] Since the modern period.
[4] We agree with Mc Comas, Clough and Almazroa (1998) on that point.
[5] The arrows are different because they are different types of interactions. Continuous double arrow: direct interaction. Dashed double arrow: epistolary interaction. Dotted single arrow: knowledge of the works. Red double arrow: interaction with controversy. Red single arrow: opposition of points of view.

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THEORETICAL MODELS FOR (MESO)CHEMISTRY: PARADIGMATIC FACTS

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Abstract: We wonder about the meaning that Chemistry can have for those who are learning it without identifying themselves with the academic pursposes of the discipline, because they are unable to, due either to their age or context (school). From this reflection, we propose a modelling orientation for chemistry teaching. We use the "theoretical model" notion from the current cognitive approaches of the philosophy of science, which propose a semantic concept of scientific theory which facilitates the approach between phenomena and the theories that explain them. We developed a chemistry at a "meso" level, which gives a very important function to the atomic theory, but not protagonisim, which belongs to "Chemical Change." The study of the exemplary changes following the rules and the languages of chemistry guides and gives coherence to the lessons, where "Ideal Chemical Facts" are built. The cognitive dimension leads us to identify the coherence between the students' experimental interventions, their abstract representations, and the languages they use to explain what they are doing, what is happening, and why it is happening. Whe identify the modelling process with the progressive fit between these three dimensions of human cognition. The discourse analysis of universitary students from a "chemistry for all" course allow us to identify the relationships the students established between their representations, experimental interventions and the languages they used.

Keywords: Chemistry, Representation, Language

BACKGROUND, RATIONALE AND PURPOSES

Research on chemistry teaching based on models has become increasingly important, due to new educational aims that require the students to be competent in the use of the scientific knowledge to their own reality. This new curricular orientation, in elementary as well as in universitary education, pushes us to urgently desing a new way for teaching chemistry. This research includes diverse fields: the study of experiences or phenomenology (Andersson, 1990); classroom discourse analysis (Mortimer, 1998); pedagogical content knowledge (Shulman, 1986); the "perspectival realism" (Giere, 1988). All of them asked themselves how the "school chemistry activity" (SCA) which makes the students put their cognitive capacities (think, do, and communicate in a coherent way) on trial is built (and developed). In order to do this, it is necessary that the experimental situations they are intervening can be mentally and simbolically represented (Gilbert, de Jong, Justi, & Van Driel, 2002), to create a standpoint for chemical-problem solution. to generate chemical approach to the phenomena. In our modelling process analysis we also apply our theoretical framework (Author & Adúriz-Bravo, 2003) and an epistemological approach as has been explained by Sénsevy (2008) et al (2009). In this paper we wonder how tuned languages, representations and experiments (LER) in a modelling process to acquire (get into) a relevant school chemical knowledge.

Framework

We present the students some carefully-chosen chemical phenomena as "problems" that provide the context and opportunity to introduce the essential and elementary and chemical ideas, which give sense to the problem; it can be solved and related to other problems important to chemistry. We "modelled this phenomenon"[1]: we "colonized" it by applying to it the chemical ideas (laws of chemical change) and by representing it, as far as possible, through atomic theory which will allow to introduce the formula language, basic to communicate "what is happening" when a chemical change takes place. Because of this, a "natural change" becomes a chemical change, that will be a MODEL to identify some others that are similar. The data presented for this communication are taken from the student's discourse regarding a phenomenon: "pyrolysis (carbonization) of wood". This phenomenon, as well as all the rest that will become "Chemical Change Models" has to follow the *"rules of the chemistry play"*:

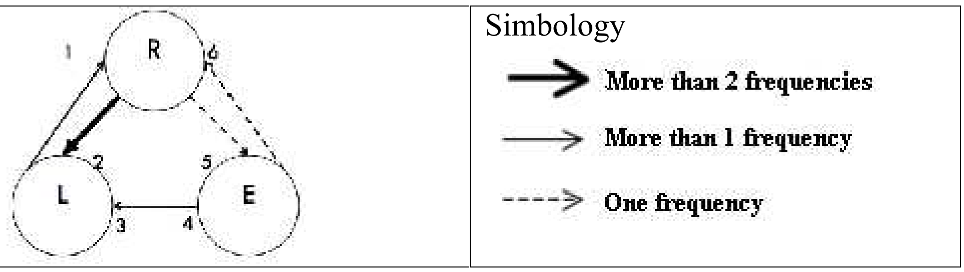
a) Some substances dissappear and others appear.
b) The elements are preserved. The mass is conserved (in atoms, including electrons)
c) The substances react in fixed proportions (chemical equations)
d) Energy is conserved (chemical bond)
e) In the final state, there is no more "chemical potential" available.

METHODS.

We had a video recording of three sessions where the students used models to explain the pyrolysis of wood and answer the teacher's questions. The students worked in three-to-four people groups. The models had been built freely with different materials (play dough, strips of paper, 3D models to represent molecules...). The recordings were transcribed and analyzed identifiying "interactivity segments" and "acting patterns": Inquiry (I), Start (S), Feed-Back (F), Evaluation (E). The dialog was coded in terms of the foreseen transitions; (L↔R; R↔E; E↔L…) and some "transition maps" were made, and then interpreted. The data were gathered from the instrument showed below (tabla 1) and were represented with diagrams (fig. 1)

Paradigm/ Sentences	Complement that enriches the explanation of the sentence	Transition L-E-R	Interpretation
Students' phrases	Elements that provide the context		

Table 1. Transition language-experiment-representation



[1] It is frequent that the models represent scientific entities as the phenomenon interpreted, and not the phenomenon itself, where the entities stem from.

Figure 1. Example diagram

RESULTS

Different diagrams that could be compared with each other (see table 2) as well as with the diagrams from the same student's discurse in different pedagogical situations were obtained. Although only in few situations all the transitions are present, we have been able to prove that in the cases where the modelling process could be applied, this was successfully accomplished (see table 2).

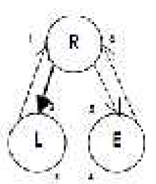
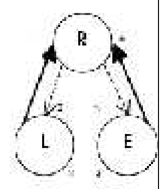
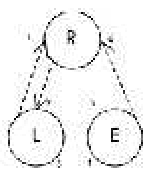
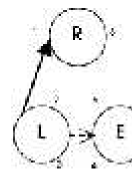
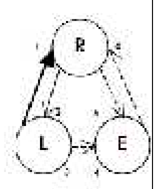
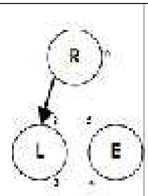
Case	Lorena	Juan	Tomas	Paloma	Maria	Marta
Representation of the transition						

Table 2. Diagrams for six students in the same class session.

CONCLUSIONS AND IMPLICATIONS

We think that choosing the pyrolysis of wood as "paradigmatic fact" was the right decision to make, because it is an everyday phenomenon that can be intervened, that starts and ends, and which also allow to mass. It requires a control (for the wood not to burn) that is available for the students and that allows them to intervene in the process in an autonomous way, and when doing so, they can recognize the combustion process. We think it interesting to have identified in the student's discourse the transitions between their references to the real phenomenon to the representation in the model and to their "giving a name" which gets more scientific as they manage to interpret the change with the entities represented by the model.

We have been able to empower the meaning of the terms: model, paradigmatic fact and representation in our research project about the "chemical chemistry" teaching. He have realized that the relationships between thinking, experimenting, and communicating based on a determined planning that gathers the phenomena in groups or "fields with the same conceptual structure", allow to rebuild "facts of the world" according to the chemical theory, that will become "Theoretical Models" of the chemical theory. What we call "School chemical-change model" gives us the conductive thread to develop the curriculum focusing on the paradigmatic examples from Chemical Change.

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STUDENTS' ANALOGICAL REASONING WHEN PARTICIPATING IN MODELLING-BASED TEACHING ACTIVITIES

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Abstract: One of the ways students can express their mental models is by drawing analogies between an already known domain and the domain of the scientific topic they are learning about. The literature stated that analogical reasoning is comprised of some sub-processes but in previous studies we have shown that in regular teaching situations, students do not spontaneously experience all of them, thus resulting in problems in students' learning. In this paper, we have identified evidence of such sub-processes in students' analogical reasoning when they participated in a modelling-based teaching about solubility that occurred in a regular classroom. From them, we discuss the influence of modelling-based teaching conducted in regular classrooms on students' experience all the sub-processes of analogical reasoning.

Keywords: modelling-based teaching, analogical reasoning.

INTRODUCTION

Analogies are relational comparisons between a familiar and an unknown domain (Duit, 1991; Gentner, 1983; Glynn, 1991). Therefore, from drawing an analogy, one expresses a partial representation of an idea. This implies that analogies are models (Duit, 1991).

Although many researchers recognise its importance, there is no general agreement in cognitive science literature (for instance, Gentner, 1989; Holyoak & Thagard, 1997; Vosniadou & Ortony, 1989) about how the analogical reasoning process occurs. In attempting to understand analogical reasoning, this process has been decomposed into basic sub-processes: (i) *access*: one or more relevant known domains should be accessed; (ii) *mapping*: one familiar domain is mapped on to the target domain by identifying systematic correspondences between them; (iii) *elaboration of inferences* about the target, favouring domain understanding; (iv) *evaluation of the match*, followed by changes in the inferences in order to fit them with special aspects of the target; and, sometimes (v) *generalisation*: extension of inferences to all cases in which they could be applied.

The drawing of analogies is a daily action of human reasoning. However, the situation is different in the context of science classrooms where, in general, teachers present analogies to students and ask them only to understand the mapping relationship. In the science education area, few studies have been conducted on analogical reasoning in which students draw, use, and modify their own analogies (Cosgrove & Schaverien, 1996; Kaufman, Patel, & Magder, 1996; Pittman, 1999; Wong, 1993). In our previous study (Mozzer & Justi, 2010), we analysed how students reason analogically when they are asked to draw analogies for a scientific target domain they are currently learning about. We showed that, in general, students have no difficulties in performing both the access and the mapping sub-processes. On the other hand, they do not perform the other sub-processes (evaluation of the match, proposition of inferences, and generalization) unless they have been specifically asked to do so. As a consequence, students may either develop alternative conceptions from improper matches between non comparable relations and/or attributes of both domains, or misuse the analogy in other contexts. This implies that if students' drawing of their our analogies is to be part of teaching activities, teachers must foster them to accomplish all the analogical reasoning sub-processes. This would favour their involvement in those sub-processes that are not spontaneous for them.

As analogies are models, one of the possible ways to involve students in all analogical sub-processes would be by engaging students in modelling-based teaching activities. According to Justi and Gilbert (2002), modelling is a dynamic and non-linear process comprised of four main complex stages: the *production* of a mental model; the *expression* of that model in any mode of representation; the *tests* of the model; and the *assessment* of the resulted model, that is, the consideration of the scope and limitations of the model.

RESEARCH QUESTION

When students participate in modelling-based activities produced and conducted from the Justi and Guilbert's perspective, they experience all these stages. As the skills involved in such experiences are, in some way, similar to those involved in analogical reasoning, we have supposed that modelling-based teaching could contribute to students' accomplishment in performing all the analogical reasoning sub-processes. Assuming this hypothesis, in this paper we discuss the following question: How can modelling-based teaching conducted in regular classrooms contribute to students' experience all the sub-processes of analogical reasoning?

METHODOLOGICAL ISSUES

Context and sample

A series of modelling-based activities was developed to support the teaching of solubility to 15-16 year-old students (Activities 1-4 in figure 1). Such activities aimed at favouring students' creation of a qualitative model that explained sub-microscopic aspects involved in dissolving. Such a teaching sequence is similar to other teaching sequences we had developed in the sense that the activities were elaborated in such a way as to favour students involvement in all stages of the modelling process. On the other hand, this teaching sequence has a unique characteristic: students are required to express their models both in a concrete mode and by drawing analogies. This is justified by our intent to investigate students' generation of analogies in a modelling context.

These teaching activities were applied in a regular class comprised of 36 students (15-16 years old) in the last month of the academic year. They had already studied properties of substances and chemical bonding around 8 months before, but from a traditional approach. As far as our data showed, initially they had several improper conceptions about both topics and none of them showed an acceptable understanding about how a substance dissolves into another. Moreover, they had previous experience with neither modelling-based activities, drawing of analogies in science classes, nor investigative experimental activities. On account of this, before the modelling-based activities, students participated in an extra activity based on the Teaching-with-Analogy (TWA) model (Glynn, 1991) involving the analogy between the solar system and the Bohr atomic model (Activity 0 in Figure 1). It aimed at facilitating students' understanding about the meaning of analogies in science.

Activity	Brief description
0	Identification of the relevant characteristics of both the Bohr atomic model and the solar system. Mapping the similarities between both domains, with special emphasis on the relational mappings. Identification of the differences between both domains.
1	Presentation of two systems (water + piece of chalk and water + powder grape

	juice) that have different behaviour in terms of the solubility of the solid material in water. Elaboration of prediction about what is going to happen in each system when their components were mixed. Conduction of the empirical experiments and registration of the observations. Discussion about possible differences between previous predictions and actual observations.
2	Elaboration of a model to explain the observed phenomena at the sub-microscopic level and expression of such model in a concrete mode of representation. Drawing of analogies to explain the represented phenomena. Identification of the similarities and differences between the aspects compared.
3	Observation of new behaviour of one of the systems (mix of powder grape juice in water without stirring the system). Attempt to use the previous analogies in order to explain the new behaviour of this system. If necessary, modification or rejection, followed by new elaboration, of previous analogies and/or concrete models.
4	Extension of possible analogical inferences to other situations related to the modelled phenomenon.

Figure 1. Brief description of the teaching activities.

Throughout all lessons, students have worked in groups comprised of 5-6 students. The teacher guided the whole process. As the chemistry teacher had no previous experience with modelling-based teaching, before the starting of the study, the first author met her twice. In such meetings, they discussed about the teaching context, the students' previous ideas related to the topic, the modelling-based teaching, students' drawing of analogies, the relationships between analogies and models, and the conduction of the modelling activities. So, these meetings were essential in order to improve the teacher's understanding on both the modelling-based teaching process and the purpose of our study. The teacher has participated in both the meetings and the lessons with great enthusiasm.

During the lessons, she has tried to favour students' discussions by stimulating them to critically analyse, to modify, and, sometimes, to reject their analogies and other models. She has also asked them: to explain their choices about modes of representation, as well as the meaning of particular codes of representation; and to explain their ideas, to think about the coherence of the ideas expressed in their concrete models and analogies. Finally, she also tried to produce generative questions – those that "cannot be answered on the basis of stored information but require the genuine solution of a new problems" (Vosniadou, 2002, p. 358) in order to favour students' rethinking about specific aspects of their models.

Data gathering and analysis

All five lessons were video-recorded by using two cameras. The videos focused on the discussion between the students in their original groups and those between the students and the teacher. Additionally, the discussions in each of the groups were audio recorded, the written material produced by the students was collected, and the concrete models they produced were photographed.

From the integration of such data, we produced case studies for each of the students' groups. The most complete of such case studies (that is, the one that include most of the moments in which students were producing and discussing their concrete models and analogies) was from a group comprised of six students. Such a case study was analysed aimed at making it evident the elements of the modelling activities that had contributed to students' experiencing of all the analogical reasoning sub-processes, and to the development of their knowledge about the dissolving process.

CONCLUSIONS AND IMPLICATIONS

From the analysis of our results (not presented here due to the limitation of space), we identify the elements of the modelling-based teaching that may have contributed to students experiencing all the sub-processes of the analogical reasoning. They are presented in figure 2. From them, we draw our conclusions and present some implications of this study.

Sub-process of analogical reasoning	Action in the modelling-based teaching	Modelling stage	Activity
Access and mapping	▪ After the observation of each phenomenon, request to produce a mental model, and to express it as concrete models and as analogies that could explain them. ▪ When necessary, request explanations about the mapping between the compared domains.	Production of mental model. Expression of the model.	1 2 3
Evaluation of the match	▪ Opportunity for students to observe new empirical evidence. ▪ Explicit request (from both the activities and the teacher) to express the similarities and differences between the compared domains. ▪ Explicit request, from the teacher, to analyse their comparisons for the new knowledge built during the class discussions.	Tests of the model.	3
Proposition of inferences	▪ Request to produce explanations based on students' previous explanations (and identified by the teacher as close to the scientific accepted ones). ▪ Teacher's elaboration of generative questions. ▪ Request to compare systems that behave differently from each other when students were already able to explain the behaviour of one of them.	Production of mental model. Expression of the model. Tests of the model.	2 3 4
Generalisation	▪ Presentation of a new context in which students could try to extend their possible inferences from the process they had experienced, thus providing evidence of the knowledge they had built during the modelling activities.	Assessment of the resulted model.	4

Figure 2. Summary of the relationships between the analogical reasoning sub-processes experienced by students in different modelling stages and activities.

Our results showed that specific requests from of the modelling activities (mainly those related to the production, expression, and tests of students' models), as well as some teacher's actions when conducting the process (mainly the promotion of discussions between students, the elaboration of generative questions, the request for explanations concerning the codes of representations used in different models, and the request for justification of all their expressed ideas) have clearly favoured the occurrence of all the analogical reasoning sub-processes (including those that are not common in students' analogical reasoning).

Besides these relationships, we can also discuss other contributions from the drawing of analogies in the modelling-based teaching context. One of them concerns the visualization of sub-microscopic entities (and relationships between them) from the observation of macroscopic phenomena (Justi & Gilbert, 2006). As those students had already studied the chemistry topic, we suppose their previous learning about it was insufficient for supporting students' production of initial representations (concrete models and analogies) at the sub-microscopic level that included information concerning the interaction between particles and the intensity of such interactions. In the teaching situation analysed in this study, when the teacher provide them opportunities to express their own comparisons, she could realise that, although they were asked to make representations at the sub-microscopic level, they established mere appearances matches (those characterised by the mapping of macroscopic properties between the compared domains). This has supported the teacher's decision of discussing the meaning of such levels, and making clearer to students what they should represent and explain in their models. Moreover, the simultaneous expression of students ideas through concrete models and analogies, and the teacher's request for explanations concerning the codes of representation used in each model have also favoured the teacher's access to some students' ideas, as well as her following actions aiming at favouring students' reasoning at the sub-microscopic level.

Our results also support our view that the use of modelling-based activities like those used in this study can facilitate the evolution from the establishment of mere appearance matches to the drawing of analogies. This is so because relational comparisons are made when a more advanced knowledge about a given domain is being developed, or has just been developed (Vosniadou, 1989), that is, when students are already able to integrate the macro and the sub-micro levels in building a more comprehensive understanding (Justi & Gilbert, 2006).

In this study, we had evidence that the modelling-based activities provided opportunities for that students experienced all the analogical reasoning sub-processes in a way similar to the one scientists experience when building scientific knowledge. Following the process of evolution of students' ideas in the direction of those accepted in science, we had evidence that the drawing, expression, and changing of students' analogies contributed to their learning about the chemical topic. On the other hand, other studies would be necessary in order to investigate if the drawing, expression, and changing of students' analogies can also support students' learning about the process of building scientific knowledge – which is also one of the aims of modelling-based activities produced from the Justi and Gibert's modelling diagram perspective.

Finally, as our study has shown, the involvement of students in all the analogical reasoning sub-process cannot be viewed as an autonomous process, that is, the teacher should guide the students in performing specific sub-processes. Therefore, it is essential to include discussions about modelling-based teaching, analogical reasoning, and teachers' actions that may foster the integration of such processes in teachers' educational contexts. This may result in the development of specific elements of their pedagogical content knowledge, which may support them in facing the challenges of conducting more authentic and effective science education.

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PROSPECTIVE SCIENCE TEACHERS' APPRECIATION OF SCIENCE: THE CASE OF THEORY OF EVOLUTION VS. INTELLIGENT DESIGN

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Abstract: The study aimed to explore the prospective science teachers' appreciation of science in the case of evolution vs. intelligent design (ID). It introduced a proxy indicator of "appreciating science" in the case of evolution theory. "Appreciation of science" was defined as recognising the value or excellence of science and therefore choosing the scientific explanation between the clashing worldviews in question. Data were collected from 31 prospective science teachers' written arguments in the context of evolution versus intelligent design (ID). Four distinct groups of claims were identified following qualitative analyses of the written arguments: (a)"Accept Evolution and Teach Evolution only", (b)"Accept Evolution & ID and Teach Both", (c)"Accept Evolution, Teach Evolution and Talk about ID" and (d)"Do not Accept Evolution and Teach ID only". We concluded that %39 of the participants did not appreciate the theory of evolution in explaining the origin of species. We also concluded that accepting a scientific theory was a necessary but not a sufficient condition for appreciating science because 32% of the prospective science teachers accepted evolution and ID as science and equated ID with evolution theory. Furthermore prospective science teachers who appreciated science and who did not appreciate science on the basis of our definition of appreciation, refer to the same aspects of nature of science (NOS) such as tentativeness and testability to justify their positions about teaching evolution and/or ID. This outcome implies that either these prospective science teachers do not have a clear understanding contemporary NOS views or these aspects of NOS are not sufficient in enhancing prospective science teachers' understanding of evolution. In the context of the broader goals of scientific literacy, one of the implications of the study is to develop and integrate activities in teacher training programs in order to enable prospective science teachers to understand the nature of scientific theories and to distinguish a theory from a pseudo scientific explanation. We suggest that improved understanding of NOS will facilitate better appreciation of science.

Keywords: appreciation of science, evolution, intelligent design

INTRODUCTION

In a scientifically literate society, people are expected to distinguish between what is science and what is not, and construe a scientific theory as the best explanation for a particular natural phenomenon at a particular time period. For instance, evolution theory is a scientific theory explaining the origin of species whereas intelligent design (ID) is a pseudo-scientific explanation about the origin of life. The ability to distinguish a scientific explanation from a pseudo-scientific explanation is an important aspect of scientific literacy. However, according to a survey in 2006, in countries such as Turkey and US, public acceptance of evolution theory is very low (Miller, Scott, & Okamoto, 2006). Peker, Comert & Kence (2010) indicated that the acceptance of evolution as a scientific theory in Turkey was low not only in public but also among undergraduate students in science education, biology education and biology. Peker et al's study (2010) illustrated that only 27.75 % of undergraduate students with a science background, who were supposed to teach evolution in Turkey, accepted evolution as a scientific theory. It is also worthwhile to note that there are wider institutional and cultural concerns that impact how evolutionary theory is perceived and communicated in Turkey. For example, in 2009, a special issue of the official magazine of the Turkish Scientific and Technical Research Council (TUBITAK) about Charles Darwin and the theory of evolution were censored just before it went to press (Nature, 2009). In addition to this censorship, ID is being disseminated in Turkey quite systematically and the social pressure increases on teachers to teach it as science. "Turkey is now a major source of the creationist propaganda outside the USA, and is especially significant in relation to its influence on Muslim populations in Europe" (Cornish-Bowden & Cardenas, 2007, p.113). These efforts are sometimes supported politically in the European Union (EU) and elsewhere. For example, in a response to an EU Resolution, European Centre for Law and Justice (2007) described ID as a scientific theory and equated it to the theory of evolution.

FRAMEWORK AND PURPOSE

Wider theoretical context for the study of scientific vs. pseudo-scientific explanations is epistemology. Within traditional epistemology, it is widely accepted that belief, truth and justification are the necessary conditions of knowledge. This is known as the justified true belief (JTB for short) theory (Musgrave, 1993). So, if knowledge is considered as one of the primary outcomes of science education, then it follows that science teachers are also responsible for facilitating their students' acquisition of scientific beliefs. However, teaching science does not guarantee a change in students' potential inconsistent beliefs especially about science topics such as evolution or astronomy. Smith and Siegel (2004) argue that science education must aim for understanding rather than knowing so that beliefs of students do not become an issue in science classes. In other words, unlike knowing, believing is not a necessary condition for understanding. Instead of believing, Smith and Siegel (2004) emphasize appreciation of justifications as one criterion of understanding. Moreover, in order to develop public understanding of science, it is "necessary for students to develop an appreciation of both the power and limitations of scientific knowledge claims" (Driver, Leach, Millar and Scott, 1996).

In the Oxford English Dictionary (2010), to 'appreciate' is defined as "to recognize as valuable or excellent". The present study introduces a proxy indicator of "appreciation of science" in the case of evolution theory. The topic of evolution is quite significant in science education as evidenced, for instance, by the dedication of a special issue of *Science & Education* Journal in 2010, and therefore perfectly fits the purpose of introducing a proxy indicator of appreciating science. Broadly speaking "appreciation of science" is defined as recognising the value or excellence of science. Moreover, Deboer (2000) suggests enhancing public understanding and appreciation of science for the larger goal of scientific literacy. For the purpose of this study we expect appreciation of science to be inclusive of favouring scientific explanations, for example, choosing the scientific explanation when presented with clashing worldviews about a critical issue. In order to promote appreciation of science in science classrooms, then, teachers would be expected to place a higher status to the theory of evolution as a scientific theory than to intelligent design. Within this framework, the present study aimed to explore the prospective science teachers' appreciation of science in the context of evolution vs. intelligent design (ID). In order to approach the research problem, prospective teachers' written arguments were investigated to outline how they chose to justify their preferences to teach evolution and/or ID in a science class. We define argument as justified claims about a position taken, in this context, claims about evolution vs. ID –a definition which is consistent with others in the literature (Erduran, 2007). Moreover, we analysed how prospective science teachers referred to widely taught aspects of Nature of Science (NOS) in order to justify their positions. Thus, it was aimed to analyse the role of their NOS views in their preferences about teaching evolution and/or ID. According to mainstream NOS views, scientific knowledge is: (a) Tentative, (b) Subjective Based on empirical evidence, (c) Theory-laden, (d) the product of human imagination and creativity,(e) inferential, (f) influenced by society and culture as well as by scientists' values and experiences (Abd-el-Khalick, 2001; Schwartz & Lederman, 2002).

METHOD

The study was guided by the following research questions: (a) What is the nature of prospective science teachers' appreciation of evolutionary theory in Turkey? (b) What is the role of teachers' views on the nature of science (NOS) in relation to their position regarding the theory of evolution?

Data were collected from prospective science teachers in a state university in Turkey. The university accepts students from all over Turkey who are successful in the nationwide University Entrance Examination. This examination is centrally organized by the Student Selection and Placement Centre every year, and all high school graduates who want to be science teachers must sit for it. Successful students may attend a four-year program in a Faculty of Education. Upon graduation, the prospective teachers in this study would be qualified to teach science in primary schools (grades 6–8). The sample comprised 31 third- and fourth-year students: 11 male and 20 female.

The participants watched the NOVA documentary film titled "Judgement day: Intelligent Design on Trial" (2007). The film problematises the teaching of evolutionary theory versus intelligent design, and is based on a true story of conflict in a community and a school district in the United States. After watching the NOVA documentary film, prospective teachers were asked to write a position paper to clarify and justify their individual positions on teaching evolution and designed in a science class. The written arguments of the prospective teachers were analysed to identify their appreciation of science. Moreover, two prospective science teachers (one who appreciated evolution and one who did not appreciate evolution) were chosen for case study analysis. In both cases, statements of prospective science teachers were scrutinised so as to reveal how their NOS views influenced their positions. More specifically, we traced how prospective science teachers referred to characteristics of science and scientific knowledge such as tentativeness, subjectivity, falsifiability, theory-ladenness, explanation of nature, natural or supernatural causality, method and inquiry processes including questioning, hypothesis, observation and data collection.

RESULTS

As a result of qualitative analysis of written responses (Table 1), four distinct groups of arguments were identified:

Group (a)-Accept Evolution and Teach Evolution only: The first group included 15 prospective science teachers. They clearly accepted evolution as a scientific theory. As for their positions on their future science classes, all prospective science teachers in this group argued in favour of only teaching evolution in science classes. Analysis of their arguments showed that they gave a higher status to the theory of evolution as a scientific theory than to ID.

Group (b)-Accept Evolution & ID and Teach Both: The second group included 10 prospective science teachers. They considered ID as a scientific theory and equated it with the theory of evolution. As for teaching evolution and/or ID in their classes they opted for teaching both.

Group (c)-Accept Evolution, Teach Evolution and Talk about ID: This group included 4 prospective science teachers. Similar to the prospective teachers in Group (a) they accepted evolution as a scientific theory and argued in favour of teaching evolution in science classes. However, differently from Group (a), they also argued that ID should be mentioned in science classes as a pseudo scientific explanation. Yet, they gave a higher status to the theory of evolution as a scientific theory than to ID.

Group (d)-Do not Accept Evolution and Teach ID only: The fourth group included 2 prospective teachers. They clearly rejected the theory of evolution based on their religious beliefs. They argued that evolution theory imposed atheism and in this sense it was also religious. They also argued that science was not able to answer the origins of life as the question was not scientific. They argued that the best role for science in this issue was to work on how the Designer created the universe. Based on these justifications they opted for not only teaching ID in science classes but also teaching against Darwinism and evolution.

Table 1. The results of the appreciation of science analysis

	Appreciate evolution		***Do not appreciate evolution***	
	Accept evolution & Teach evolution	*Accept evolution & Teach evolution and mention ID*	*Accept evolution & Teach both evolution and ID*	*Do not accept evolution & Teach ID and mention evolution*
Total (n)	15	4	10	2
Total (%)	48.4%	12.9 %	32.26%	6.5 %
Total (%)	61.3 %		38.70 %	

Case Study Analysis

Two cases of prospective science teachers were selected for a detailed analysis of the role of nature of science (NOS) views in justifying their positions in teaching evolution and/or intelligent design in a science classroom.

The first case is from group (a), therefore, classified as “appreciates evolution”. The prospective science teacher argued that evolution was a scientific theory whereas ID was not science. Therefore, he preferred teaching evolution theory. While justifying this position, he referred to certain aspects of NOS. These included definition of ‘theory’, tentative, testable, and falsifiable nature of science. Regarding NOS he stated:

> *Yes, t**heory** is not a fact but it is the best explanation we have about the rules of nature. ...all scientific explanations are **tentative and testable** ...scientific knowledge should be **testable, falsifiable** and **tentative.***

While arguing against ID he stated:

> *The followers of intelligent designers do not have much scientific data or explanations... ID is not a scientific explanation or a theory because all scientific explanations are **tentative and testable**...The proofs of ID were not scientific because scientific knowledge should **be testable, falsifiable and tentative**.*

The second case is from group (b), therefore classified as "does not appreciate evolution". This prospective science teacher argued that both evolution and ID are scientific in nature. Therefore, he opted for teaching ID as an alternative theory to evolution. Regarding NOS, ID and evolution he respectively stated the followings:

> *Scientists are not totally **objective.** They defend their own **theories.** But science is **objective**. In order to be **objectiv**e students should learn different points of view.*

> *ID proponents say that "nature of an intelligent cause or agent may not be directly **observable**, its effects on nature can be detected. When we think about these, it can be considered as science. İt[ID] is just a **theory** and it is one of the explanations of origins of species. You are free to believe whatever you want…Evolution theory can be considered as science because some concepts of the theory are **observable** by the methods of science.*

> *Some scientists accept this theory [evolution] as valid because of existence of many **evidences** that support the theory. Despite there are **evidences** about the theory, every new findings has potential to refute this theory **[tentativeness**]*

So, according to this case, in order to be objective, students should learn both points of view. In this sense, they possess an equivalent position in the science classroom. While justifying this position, he referred to certain aspects of NOS such as objectivity, observable, evidence, and tentativeness, some of which were the same aspects as in Case 1.

CONCLUSIONS AND IMPLICATIONS

If prospective science teachers appreciate science and a group of prospective science teachers is examined in terms of their positions about teaching evolution and ID as science, then it is expected that they would favour evolution compared to ID in a science class. However in the present study, 38.7% prospective science teachers preferred teaching both or only intelligent design as a scientific theory. Therefore, the group of prospective science teachers did not appreciate science in the sense that we are considering "appreciation of science". Hence, based on the results of the study**,** we conclude that the prospective teachers in the groups (a) and (c) appreciate science (as specified in our conceptualisation "appreciation of science") whereas the participants in the group (b) and (d) do not appreciate science. Considering that all participants are prospective science teachers, the ratio who do not appreciate evolution theory can be considered to be quite high and thus of concern.

We also concluded that accepting a scientific theory was a necessary but not a sufficient condition for appreciating science. In other words, % 32 of the prospective science teachers accepted evolution in group (b). However, group (b) also accepted ID as science and equated ID with evolution theory. So, acceptance of evolution by itself might be a misleading criterion for science educators. Instead, appreciation might be a better criterion for evaluating the case of evolution/ID. Moreover, from the case analysis, it was seen that prospective science teachers who appreciate science and who do not appreciate science refer to the same aspects NOS such as tentativeness and testability to justify their positions about teaching evolution and/or ID. This implies that either these prospective science teachers do not have a clear understanding contemporary NOS views or these aspects of NOS are not sufficient to enhance prospective science teachers' appreciation of evolution. Therefore there is a need for further studies about the role of prospective science teachers' NOS views in their appreciation of science.

As for the goal of scientific literacy, the implications of the present study are at least two-fold. First, activities, which enable prospective science teachers (a) to understand broader aspects of a scientific theory and (b) to distinguish a theory from a pseudo scientific explanation should be developed and included in teacher training programs. Second, as accepting a scientific theory is not a sufficient condition for scientific literacy, teacher training programs should emphasize appreciation of science to ensure that future teachers recognise the value and excellence of science.

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OPENING UP VALUES THROUGH HISTORY AND PHILOSOPHY OF SCIENCE

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Abstract: The 30 month, 8 country, EU History and Philosophy in Science Teaching (HIPST) project was established in February 2008. the UK part of the project has focused on three themes: a) the role of measuring in characterising the concept of temperature in history; b) induction as a historical method for establishing concepts of acidity; c) the historical use of the paper tools of chemical formulae and chemical equations to promote thinking about chemical processes. The first two themes are suitable, and are being trialled in lower secondary schools, with 5 comprehensive classes of Year 7 (11/12 year old pupils), in the South of England. the third theme is suitable for upper secondary pupils.

The materials produced for the first theme have been trialled and reviewed. The results so far have established the strength of a collaborative two cycle approach, involving a researcher from Higher Education, and practicing teachers in schools, producing relevant and robust resources for subject knowledge and the Nature of Science. Co-teaching has proved to be a successful tool for improving and increasing teacher subject knowledge about science and the history of science. Equally valuable, co-teaching has been a successful method for introducing pedagogical innovation, in comparison with a wiki, which has been less well used.

Pedagogical innovations that have engaged most pupils have included producing play scripts of scientific stories, and newspapers written in simple language. Using pupil work as a source of material for newspapers has also been an important innovation. the pupil newspapers have also served as a source of information for the teachers. Some new activities have been developed: lack of equipment in schools and skills of technicians was a barrier, and has led to specific training for the latter.

INTRODUCTION

The science education community's values are embedded, often implicitly, in its intended curricula. For example, the Science National Curriculum in England for 11 – 14 year olds (QCDA, 2009) states that: 'Pupils learn how knowledge and understanding in science are rooted in evidence. They discover how scientific ideas contribute to technological change – affecting industry, business and medicine and improving quality of life. They trace the development of science worldwide and recognise its cultural significance.'
Under Cultural Understanding, the same National Curriculum requires pupils to ‘recognise that modern science has its roots in many different societies and cultures,

and draws on a variety of valid approaches to scientific practice'.
The American Association for Advancement of Science (Project 2061) (AAAS, 1993, 2009) has 'The images that many people have of science and how it works are often distorted. The myths and stereotypes that young people have about science are not dispelled when science teaching focuses narrowly on the laws, concepts, and theories of science. Hence, the study of science as a way of knowing needs to be made explicit in the curriculum,' with development of some of the history to exemplify what should be done. Within the domain of History of Science, we seem to have variable and often rather weak guidance on its inclusion in Science Curricula.
Williams (2002) surveyed the history of science in textbooks in England in 1999, following the integration of science into the mainstream school science curriculum. He notes that, in the related history curriculum, pupils have to have: chronological understanding; knowledge and understanding of events, people and changes in the past; historical interpretation; historical enquiry; and organization and communication. He used this framework to assess the place of history of science in readily available textbooks. His conclusions included (page 90):

- 14 – 16 physics has a larger volume of unexplained names in the history of science than biology and chemistry;
- the history of science is often included as a non-essential 'add-on' and serves little purpose in developing ides and/or concepts;
- few accounts of the lives of scientists are given or how they worked;

Höttecke (2009) in his ESERA paper acknowledged the importance of History and Philosophy of Science towards school teaching, and the dearth of research about and curriculum resources for HPS teaching in schools. Höttecke gave the following research analysis of the impact of teaching HPS in Physics.

RESEARCH QUESTIONS

1. What are the purposes of including History and Philosophy of Science (HPS) in school curricula? What HPS is embedded in curricula?
2. What is presently known about the effect of HPS teaching in schools?
3. How do teachers respond to an explicit HPS teaching programme?
4. How do young learners respond to an explicit HPS teaching programme?

METHODOLOGY

1. The author undertook a desk study of National Curricula for Science, and of textbook resources. This was supplemented by a national meeting of researchers. teacher trainers, a philosopher of science, textbook writers, members of learned scientific societies, and a museum presenter.
2. The author undertook a desk study of literature relating to the effect of HPS teaching in schools
3. Three teachers undertook to teach a module on temperature to explore the effect of measuring on validating, and developing the reliability and accuracy of scientific equipment. The teachers took part in discussions by email, face to face conversations

that were recorded by hand, and one by constructing a reflection log
4. Teachers in two schools volunteered to trial materials with a total of 150 pupils aged 11-12 years old. Data collection included open-ended written questions, recording of learning in notebooks, field observations by the author, debriefing discussions by the author that include reports agreed with the teachers, pupil play scripts about a historical event, and a pre- and post-test about pupil views on HPS.

DETAILS OF THE PROGRAMME

The project that includes this work is part of the EU funded (FP7) History and Philosophy in Science Teaching (HIPST) project (HIPST, 2008-2010). The project is led from Germany and has activities in 8 European countries devoted to producing trialled resources for teaching HPS in schools, museums and universities. The project also aims to develop teachers' personal subject matter knowledge, pedagogical skills, especially in using innovative methods, and to introduce explicit historical and philosophical thinking into science teaching. In the case of philosophical considerations, this is directly linked to the Nature of Science, and in particular in the UK to the How Science Works part of the prescribed curriculum.

The UK part of the programme has three active themes:
a) historical characterisation of concepts through measuring, in the context of temperature;
b) historical conceptual identification and change, in the context of acidity;
c) historical development and use of paper tools, in the context of chemical formulae and chemical equations.
Themes a and b are being conducted with pupils in lower secondary schools, Theme c will be conducted in both lower and upper secondary schools. This paper focuses mainly on theme a, and is partly work in progress.

The topic of measuring is part of basic scientific training in UK lower secondary schools. Pupils have studied particle ideas as concepts, and it is important that the curriculum topic meshes with the stated curriculum.

Philosophical issues
a) What are the purposes of measuring in the scientific community?
b) What is meant by validity, reliability and accuracy in scientific measurement?
c)

Historical issues
a) Is the human body a valid, reliable and accurate thermometer?
b) What is meant by standardisation, and how was it carried out for liquid-in-glass thermometers?
c) How was the constant-volume gas thermometer developed and used?

Teacher materials
A web site (www.ukhipstinstruments, wikispaces.com) has been constructed for teachers engaged in the project. The web site has these major components:

a) a teachers' subject knowledge section incorporating scholarly material on subject matter knowledge about temperature, research on typical misconceptions, pedagogical content knowledge, and philosophical information,
b) a context section incorporating historical chronological information about scientific discoveries, significant cultural events and significant political events,
c) a scheme of work to show lesson progression with conceptual, misconceptions, historical elaboration, and philosophical elaboration,
d) a teachers' section that elaborates each lesson in turn.
In addition, the project has produced simple newspapers. There are staff newspapers to share nes about the project as it progresses in schools. There are pupil newspapers, with relevant historical information about how temperature was measured in history, puzzles for pupils, reports of pupil surveys with friends and parents about what temperature is and how scientists measure, and a selection of play scripts about Gmelin's expedition across Siberia at the behest of Catherine the Great. The play plots Gmelin's report of the lowest temperature of -84.4C and the subsequent comment 50 years later by Thomson that the mercury would have frozen before then. The play scripts are used as a measure of pupil understanding of a problem in measuring temperature.

EVIDENCE

This report is based on the work of three teachers in two UK comprehensive schools, working with a total of five classes of 11-12 year old pupils, grade 7. Approximately 140 pupils have been involved so far. The study is still in progress. Up to date data and interpretation will be available for the conference.
1.
The Science National Curriculum in England for 11 – 14 year olds (QCDA, 2009) states that:
'Pupils learn how knowledge and understanding in science are rooted in evidence. They discover how scientific ideas contribute to technological change – affecting industry, business and medicine and improving quality of life. They trace the development of science worldwide and recognise its cultural significance.' It also states that pupils should be 'using scientific ideas and models to explain phenomena and developing them creatively to generate and test , and be critically analysing and evaluating evidence from observations and experiments'.
Under Cultural Understanding, the same National Curriculum in England requires pupils to 'recognise that modern science has its roots in many different societies and cultures, and draws on a variety of valid approaches to scientific practice'.
Internationally, there are variations in the emphasis paid to these issues. In recent Australian proposals, science is simply described as a 'human endeavour' with little reference to any historical outworking of this process. The New Jersey elaboration of the US Framework for Science states one aim of science is 'to show students that scientific ideas and theories have a history of their own by tracing the evolution of our most important present-day paradigms' (New Jersey, no date) The American Association for Advancement of Science (Project 2061) (AAAS, 1993, 2009) has 'The images that many people have of science and how it works are often distorted. The myths and stereotypes that young people have about science are not dispelled when science teaching focuses narrowly on the laws, concepts, and theories of science. Hence, the

study of science as a way of knowing needs to be made explicit in the curriculum,' with development of some of the history to exemplify what should be done. Urevbu and Omoi (2005) describe in detail one approach to using the history of science in Nigeria in their paper delivered to the IHPST 2005 Leeds conference but do not provide evidence of success.
Williams (2002) examined UK science textbooks for history of science content. The minimal content was an add-on, with little of the context in which the scientists worked, or about them as human beings. The history content is hardly used to develop conceptual understanding. Regrettably, there also significant numbers of errors in many textbooks.

2. Relatively little research is known about the effect of teaching HPS in schools and that which has been so far explored has mainly been in the physics domain (e.g. Höttecke, 2009 and Galili, 2009). Many researchers assert potential benefits, such as exploring difficult concepts through historical data, but there is only very modest evidence of success in this area in the literature (but see Wandersee, 1986, for one such example).

3. The teachers taking part in the trials programme are volunteers, so generalisation to other cases can not easily be made. However, these are the most positive conditions, so lack of success in these cases would be a serious setback. The main teacher in one school is a senior science teacher, and in the second school the main teacher is strongly supported by the leader of the science department. The teachers readily accept their initial lack of knowledge about the history of science, hence the production of pupil newspapers for the teachers' knowledge as much as for the pupils. They also accept their initial lack of knowledge about the philosophy of measuring, which has been developed through discussion with the author. A paper on measurement has been incorporated into the temperature wiki. The teachers claim, with strong justification, that lack of time in the face of persistent and demanding requirements for bureaucratic reporting make it difficult for them to devote significant time to studying for the project. Co-teaching, by the researcher and the teacher of each class, has been the major input source for their learning of historical and philosophical knowledge and of innovative pedagogical methods. Other sources of information, such as the web site, have played a very minor role so far, from debriefing interviews with the teachers.

4. There has been a wide variation in the way that pupils have engaged with the course. The increased emphasis on an adequate literacy base for pupils involved in the project has meant some difficulties, especially for some boys who seem to be the ones with the most serious problems in this regard. This has led, in some classes, to distracting behaviour by these pupils. The project has adopted a pragmatic approach to partially addressing the literacy issue by simplifying the language used, for example in the project pupil newspapers. However, the project participants have agreed that there is a limit to the extent that this can be done without compromising the accuracy of the ideas involved. This has meant that a small proportion (perhaps three or four in each class) have been somewhat disenfranchised from accessing some resources, such as the newspapers. Nevertheless, the great majority of the pupils show a positive attitude, in asking questions, in engaging with the practical work, in carrying out extra work at home, and in putting in extra personal time to completing play scripts. That these are often girls is only to be expected from the results of the

ROSE survey (ROSE, nd), that indicates girls dominating interest in humanistic science, and in more creative methods of recording their findings. Pupil recording of their findings in the form of annotated drawings suggest that the majority are understanding the science, the history and the philosophy in the lessons. The issue of literacy is a factor with a few pupils in the project recording their data, so that this evidence can not be collected from all.

CONCLUSIONS

The project has been successful in these respects:

1. Appropriate resources have been produced for teachers and pupils.
2. A rich dedicated web site has been provided, providing suitable guidance for both teachers and pupils.
3. The project is rather unusual (Innovative) in that the teachers are highly influential in the progress of the trials and resource production. This collaborative action between a colleague in Higher Education and teachers in schools is rather unusual.
4. The resources provided are innovative in a number of ways:

a) the use of web sites with optional information and opportunity for blogs, discussion and teachers to create their own pages and upload their own files is innovative;
b) the use of newspapers for revealing history of science, in pupil-level language, is unusual;
c) the use of newspapers in which teachers and pupils can make their own contributions, is innovative;
d) recreating historical experiments is unusual
e) the use of play scripts for recording and assessing learning is unusual
f) the use of newspapers for dissemination of progress to project members, including teachers, is unusual.

IMPLICATIONS FOR TEACHING

The project represents work in progress. Nevertheless, there are some clear implication from the project to date:

1. More resources for teaching HPS are needed and have been provided by the project.
2. Co-teaching is a powerful method for developing teachers' subject matter knowledge and innovative pedagogical skills.
3. Curriculum materials that mesh with the curriculum are more likely to be readily accepted.
4. Teachers need more time if curriculum change is to be securely embedded.
5. Individual pupil difficulties with literacy is a major barrier to engagement with science.
6. Some innovative pedagogies such as producing play scripts, and newspapers, can support increased engagement by pupils.
7. The project has unearthed some insecure learning in particle ideas that limit application e.g. use of the gas thermometer. The project has demonstrated a requirement for some changes to teaching the existing curriculum.

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IBERIAN-AMERICAN STUDENTS' AND TEACHERS' PERCEPTIONS ABOUT GENDER EFFECTS IN SCIENCE

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Abstract: In the Latin-American Project of Evaluation of Attitudes Related to Science, Technology and Society (acronym in Spanish: PIEARCTS), teachers and students from different countries were asked about their opinions on gender differences regarding Science. More than thirteen thousand students and teachers participated in the project. In this work, we analyze the results obtained by means of the Questionnaire of Opinions on Science, Technology and Society regarding the Internal Sociology of Science, focusing on two items, which inquire about the characteristics of scientists: Gender Equity (GE) and Women´s underrepresentation (WU) in Science. The results show that, in the overall sample from the different countries, the question on GE appears among those which present more positive attitudes in almost all the countries. On the other hand, as regards WU, Spain and Colombia present the most positive attitudes, whereas Brazil is among those with the most negative views. Nevertheless, the sentences corresponding to these topics appear both among the more positive and among the most negative. Women seem to be more conscious than men of the fact that the relationship between women and Science continues to be problematic. In the majority of the variables where they have found significant differences between women and men, it is the women who show a more suitable attitude.

Keywords: gender equity, nature of Science, Science – technology – society, evaluation of conceptions, teachers' thinking.

BACKGROUND, FRAMEWORK, AND PURPOSE

The traditional view of Science is shown as neutral, rational and objective, and, even if this conception has been modified thanks to the critical trends of Philosophy of Science, which considers Science a human activity (Toulmin, 1972; Fourez, 1992; Feyerabend, 1978) and, therefore, intrinsically subjective and dependent on the values of the people who construct it and on the theories on which it is based. The image or model of Science expressed by the majority of the people does not concur to these critical trends. One of the conceptions that stand out is a stereotyped model which conceives Science as the search for the objective truth about the physical world with an androcentral, positive and mystified view of this discipline that portrays man as the conqueror and controller of nature (Solsona, 2002, p.49). Teachers´ view of Science is very important since it is transmitted to students and; thus, it is disseminated and perpetuated. This transmission of the views towards Science regarding gender is often produced without the teachers' conscious awareness, since it is also supported of by the use of sexist language on textbooks and other curricular material.

During the last few years, studies about the situation of female scientists in Spain done by the Spanish Foundation for Science and Technology (Spanish acronym: FECYT) (2005), as well as in Latin America (Pérez Sedeño & Gómez, 2008), indicate that women are under represented in great part of the scientific disciplines. Opinions about this situation show that these realities are usually considered natural and inevitable. To modify this situation in the Scientific sphere, a change in the sphere of Education must be produced. One of the most important demands that are done to the educational system is related to the real capacity which the system has of being a tool that guarantees equality of opportunities (Freire, 1996). According to Subirats (2006, p. 229) “the path that is taking us from a situation of marginality and subordination to a situation of autonomy and intervention in mass decision-making processes is started through the educational system …”

RATIONALE

In this work we will present and analyze teachers´ and students´ opinions about gender equity and women under-representation in Science. These opinions were drawn from the corpus of the Latin American Project of Attitude Assessment about Science and Technology (Spanish acronym: PIEARCTS). The teachers who participated in this project work at the primary, secondary or higher educational level and come from all kinds of backgrounds. The students participants from different countries and are either finishing high school or attending university. Our objective is to show a diagnosis that allows us to answer, among others, the question posed by Ana Sánchez Bello (2002): What is the educational system’s failure since situations of social inequality regarding gender still continue to happen?

METHODS

Sample and instrument

This paper draws data from the international cooperative research project PIEARCTS, which intends to identify the nature of Science and Technology (NoS&T) beliefs across seven Iberian-American Spanish and Portuguese-speaking countries. NoS&T conceptions are assessed through the Questionnaire of Opinions on Science, Technology and Society (Spanish acronym: COCTS) (Manassero, Vázquez y Acevedo, 2003). This research tool allows easy and reliable applications to large representative samples. The PIEARCTS research team consensually selected 30 items that accomplish a balanced coverage of Science, Technology and Society issues. These items were distributed into two 15-item paper and pencil research booklets (F1 and F2). The participants in the study were 13,146 students and teachers (practitioner and pre-service) that anonymously completed a booklet, whose responses are scaled into a set of attitudinal indexes. Each participant responded one of the two questionnaires; approximately half of the participants answered Form 1 (7094), and the rest completed Form 2 (6052). In this work the results obtained in two items regarding the Internal Sociology of Science are analyzed, the first item refers to Gender equity (GE) and the second to Women´s underrepresentation (WU) in Science. As regards GE, participants are asked to reflect their opinion on the following:

- *Working in Science or technology, women would make a good scientific work in much the same way that a good scientific man:*

There are no differences between men scientists and women scientists in terms of the way they do Science:

A. because all good scientists do the work in the same way
B. because men scientists and women scientists have the same pre-service
C. because, above all, men and women are equally intelligent
D. because men and women are equal in terms of what it takes to be a good scientist
E. because we are all equal, regardless of the work we do
F. because any difference in the way that scientists work in Science are due to individual differences. Such differences have nothing to do with being male or female

G. Women in Science would work somewhat differently, because by nature or education women have different values, opinions, perspectives or characteristics (such as patience)
H. Men would work in Science a little differently, because men perform this type of work better than women
I. Women in Science would probably work better than men, because women must work harder in order to compete in a male-dominated field, such as Science.

In terms of women's under-representation (WU) in Science, the participants were presented with the following scenario:

- *Today in our country, there are much more men than women scientists. The MAIN reason for this is*:

men are strongest, fastest, brightest and better to concentrate on their studies

A. men seem to have more scientific capacity than women, women may excel in other fields
B. men are more interested in Science than women
C. the traditional stereotype that exists in society is that men are smarter and more dominant while women are weaker and less logical. This belief has resulted in more men becoming scientists, although women are as capable as men in Science
D. schools have not done enough to encourage women to choose Science courses. Women are as capable as men in Science
E. until recently it was thought that Science was a vocation in men and it was expected that most women work at home or in jobs traditionally performed by women, so the public image of Science has discouraged women -while encouraging men- to become scientists. But this is changing today: Science is becoming a vocation in women and more and more females are expected to work in Science
F. women have been discouraged or not allowed to enter the scientific field. Women are just as interested in Science and just as capable of doing so as men are. However, established scientists (who are men) tend to discourage or intimidate potential women scientists
G. There is NO reason to have more men scientists than women scientists. Both are equally capable of being good at Science and the opportunities today are similar

Procedures

The respondents rate their agreement on a scale from 1 to 9, in which 1 is used to show total disagreement and 9 to show total agreement, on each sentence item. These items are scaled into quantitative homogeneous attitudinal-belief indexes (-1, +1), whose meaning represent the grade of correctness, according to the current knowledge from History, Philosophy and Sociology of S&T (Vázquez & Manassero, 1999; Vázquez, Manassero & Acevedo, 2006). Besides, the participant's understanding of NoS&T is further represented by three indexes for the three categories in each item and the whole item index. This plan describes the participant's thinking by means of over one hundred and fifty invariant indexes (sentence, category and item indexes).

The index scores allow the use of inferential statistics for hypothesis testing, which can be applied to compare groups (last-year high school vs. last year-university students, pre-service vs. in-service teachers), or to set up cutting points for identifying the strengths (highest positive), weaknesses (lowest negative), and neutral beliefs (Vázquez, Manassero & Acevedo, 2006). The criteria to achieve relevance are the statistical significance ($p < .001$), and the effect size of the differences (differences measured in standard deviation units; $d > .30$).

RESULTS

In the overall sample of different countries, there are more positive GE attitudes in almost every country (except Mexico) and more positive WU attitudes in Spain and Colombia. On the other hand, these attitudes are more negative in Brazil. Nevertheless, sentences regarding these items appear both among the most positive and the most negative attitudes.

The attitudinal indexes of sentences that have the highest scores and positive above the cut point (half of standard deviation) are:

- To GE item, sentences D and F (Argentina, Colombia, Mexico, Spain and Portugal), and H (Argentina, Colombia, Spain and Portugal).
- To WU item, sentences A (all the countries), B (Argentina, Brasil, Colombia and Spain), C (Brasil, Spain, Mexico and Portugal), E (Brasil), F (Brasil and Colombia) and G (Brasil).

The attitudinal indexes of sentences that have the lowest scores and negative below the cut point (half of standard deviation) are:

- To GE item, sentences A (Argentina, Colombia, Spain and Portugal), C, B and E (Argentina, Colombia and Spain) and I (Colombia).
- To WU item, sentences H (Argentina, Spain, Portugal and Brasil).

Differences between groups of teachers

In Table 1 we show the results obtained for each of the countries, in terms of the index average for the whole item and to the standard deviation units of both items, for the groups of Exact and Natural Sciences (Science) and Human and Social Sciences (Non-Science), with the statistical significance corresponding to the differences between both groups.

Table 1. Results of Science and Non-Science Groups of all the countries

Country	Science		Non-Science		Signific.
	Average index	Standard deviation	Average index	Standard deviation	
Gender Equity Item					
Argentina	0.203	0.227	0.190	0.235	0.620
Brazil	0.090	0.305	0.132	0.317	0.198
Colombia (B.)[1]	0.103	0.277	0.145	0.293	0.177
Colombia (I.)[2]	0.076	0.285	0.095	0.270	0.453
Spain	0.234	0.219	0.179	0.249	0.0001
Mexico	0.140	0.276	0.096	0.230	0.131
Portugal	0.118	0.284	0.269	0.284	0.068
Women under-representation Item					
Argentina	0.139	0.339	0.146	0.349	0.850
Brazil	0.155	0.237	0.180	0.257	0.362
Colombia (B.)[1]	0.165	0.213	0.174	0.226	0.715
Colombia (I.)[2]	0.179	0.217	0.150	0.232	0.162
Spain	0.181	0.305	0.161	0.318	0.289
Mexico	-0.023	0.304	0.028	0.293	0.433
Portugal	-0.069	0.303	0.132	0.261	0.001

[1] Bogotá, [2] Ibagué

In the GE item, there was a statistically significant main effect (less than 0.001), between the group of Science and Humanities and Non-Science only for Spain, where the group of Science showed the most adequate attitude. In fact, this group has shown the most adequate attitude of all countries. As regards the WU item, there were significant differences between the complete samples of Science and Non-Science in Portugal, where the group of Non-Science showed the most adequate attitude between the two of them. Concerning this item, the group of Science from Spain has shown a more adequate attitude.

Differences within the sample of Science

Among students

Taking as the unit of analysis the results on the issues, there is a significant difference only in the items of GE for students from Spain, where older students show a more appropriate attitude than young students. Table 2 shows GE and WU items where significant differences were found between the senior students (S2) and young students (S1), and where the attitude of the S2 group from the stated country was more appropriate.

Table 2. GE and WU sentences with significantly most appropriate attitudes of S2 group

Item/Sentence	A	B	C	D	F	G	H
GE	-	-	-	-	Spain	Argentina	Spain
WU	Brasil and Spain	Brasil, Colombia and Spain	Spain	Portugal	-	-	-

If we consider the GE item, no sentences were found where the attitudes of the S1 group from any country were more appropriate. With regard to the WU item, only in sentence "I" have we found a more appropriate attitude in a S1group, the group from Brazil. These results suggest that the only country where university studies prompt the construction of a more appropriate attitude by students towards the GE item is Spain (Argentina one sentence).

On the WU item, it is worrying that in Argentina and Mexico no significant differences among young and senior students were found. Moreover, we have only found improvements in a few sentences in other countries (again it seems that it is in Spain where university studies have the most positive impact).

Among teachers

Regarding the GE item, there is only a significant difference between in-service teachers (T2) and pre-service teachers (T1). In Brazil, the most adequate attitude is shown by the T1 group. Concerning the issue of WU, there is a significant difference in Argentina, it was the T1 group the one that showed a most adequate attitude.

With respect to the sentences in Table 3, there are GE and WU items where significant differences were found between in-service teachers (T2) and pre-service teachers (T1) and where the attitude of the T2 group from some countries has been shown more suitable.

Table 3. GE and WU sentences with significantly more appropriate attitudes T2 group

Item/Sentence	A	B	C	D	F
GE				Brasil	Brasil
WU	Argentina and Brasil	Arg. and Brasil	Arg. and Brasil		Brasil

Significant differences were found regarding the GE item, with most adequate attitudes by the T1 group in sentence C in Spain, and G and H sentences, in Brazil.

According to these results, the only country where there are differences with opposite variations in some sentences of GE items is Brazil, where the T1 group has a more adequate attitude on the item as a whole, but the T2 group has a higher index in sentences D and F. In Argentina and Brazil, the experience of teaching seems to improve teachers' attitudes toward the WU item (the same happens also in Spain, but regarding only one sentence).

Between women and men

Table 4 shows the countries where we have found significant differences between the views of men and women for GE and WU items, and women have shown a more adequate attitude than men have.

Table 4. Significant differences in GE and WU items

	More adequate attitude by women
GE	S1 Group Brasil, Students (S1 and S2) Portugal, T2 Group Mexico
WU	Total sample Spain, Argentina and Mexico, S1 Group Spain, S2 Groups Spain, Argentina and Brasil; T1Group Spain

On the responsibility of the school

In terms of the items which address the issue of WU, sentence E refers to the responsibility of the school in this situation. This sentence has only appeared in the list of those who obtained the most positive attitudes in Brazil. Because the surveyed population corresponds to the educational sector, it seems important to emphasize which were the groups that showed significant differences in this sentence; namely:

- The S2 groups from Spain and Portugal, and the T2 Group from Spain, where more adequate attitudes was shown by the Non-Science sample.
- The S1 group from Portugal and T2 group from Spain, where men's attitudes were more adequate than women's.

These results demonstrate that only the younger students from Portugal, the senior students of Non-Science from Spain and Portugal, the in-service teachers of Non-Science (particularly men) believe that schools have not done enough to encourage women to choose Science courses, even though women are as capable as men in Science.

CONCLUSIONS AND IMPLICATIONS

The results show that some naïve views about the relationship between women and Science still persist nowadays; furthermore, it is also noteworthy that students and teachers display somewhat different views. Positive attitudes have been detected towards the following issues:

- Equity between women and men in terms of what it is needed to be a good scientist
- The fact that differences in the way scientists work in Science are due to personal differences, regardless of gender
- The fact that men and women work equally in Science
- The fact that the causes for the number of males scientists being much higher than women scientists ARE NOT related to men being stronger, faster and more brilliant or have no difficulties in concentrating on studies
- The reason for which there are far more male scientists than female scientists IS NOT that men seem to be more scientifically capable than women

Some negative attitudes towards these issues still persist, for example in terms of the perceived differences between male scientists and female scientists, regarding how they do Science because:

- They do not work the same way
- They do not have the same studies
- Men and women have not the same IQ
- Men and women are not equal; they depend on the job they do.

In the European countries which were part of the PIEARCTS Project, as well as in Brazil and Mexico, the surveys show more positive attitudes towards the idea that the reason why there are more male scientists than female scientists is NOT because men are more interested in Science than women. It is evident that in these countries, there is an increasing awareness of the fact that Science is a social activity and is, therefore, the predominant ideas in society are influenced by this awareness. Few differences were found between senior undergraduates and young students; this seems to show that higher education is not contributing to improve the students´ attitudes regarding Gender Equity and Women under-representation in Science.

However, future female and male teachers from some countries (Brazil, Colombia and Spain) seem to be aware that women under-representation in Science is not a natural matter, but a situation caused by an androcentrist culture which has been perpetuated for centuries. Accepting this fact is the first step towards promoting a change in this situation.
Considering gender among the people in the educational area, it is possible to establish that women appear to be more aware than men of the fact that the relationship between women and Science is an unsolved issue. This is shown by the fact that the majority of the variables where differences have been significant between men and women, women are the ones who show more adequate attitudes. This is a positive sign because they can promote a change in attitude in the rest of the people they have an impact on (children, students, partners, etc.).

To conclude, we should engage in a serious and deep reflection about the role that schools have played in the reproduction of the distorted view of Science as neutral. The more positive attitudes about the responsibility of schools in having discouraged women from choosing Science courses have been shown by groups from Spain, Portugal and Brazil - which is a serious wake-up call for the rest of the American countries-, and mainly by young male students, male and female senior students and male and female teachers of Human and Social Sciences. It is striking to note that those more involved in Science education in primary schools were women, and in secondary schools and university it was Exact and Natural Sciences teachers.

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"SCIENTIFIC INQUIRY PRACTICES OF WORKSHOP EXPERTS FOR ELEMENTARY STUDENTS IN MEXICO"

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Abstract: In this research, we characterize Scientific Inquiry practices of workshop experts for elementary students in Mexico in a teaching-learning science programme that provides scholar science and mathematics activities directed to children guided by a set of Workshop Experts, whose role is to head the workshops.

To characterize scientific inquiry practices, for four selected workshop experts, a session with children was recorder and analysed using *The National Science Foundation* (1999) teacher inquiry indicator's guide that look for special characteristics in the classroom.

This research shows that the Workshop Experts have evolved in their behaviour and actions, from a more participant and directive approach to an assessing and guiding role that involved listening and observing the student actions and interaction. The workshops experts aided with inquiry lesson materials and with a formation programme can produce a learning context that can be categorized by the indicators as inquiry based teaching and learning. It seem that with time, more formation's phases and experience immersed in an inquiry programme, inquiry actions can be performed by a teacher with better results.

Keywords: Scientific inquiry learning, elementary school, science teaching, inquiry indicators, inquiry practices.

BACKGROUND, FRAMEWORK, AND PURPOSE

Scientific inquiry is a concept that was presented for the first time in 1910 by John Dewey; since that time different educators have use it. For example, Joseph Schwab (1960, 1966) was an influential voice in establishing the view of science education through inquiry. He suggested that teachers should present science as inquiry and that students should use inquiry to learn science subject matter. To achieve these changes, Schwab recommended that science teachers should look first to the laboratory and use experiments to lead, rather than to follow, the theoretical classroom phase of science teaching.

In 1996 the National Research Council (NRC) presented a specific definition of inquiry, in which teachers can and should promote the curiosity and the development of the students' abilities regarding to inquiry. Inquiry is defined as:

> The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as a comprehension of how scientists study the natural world (NRC, 1996: 23).

Anderson in 2007 emphasizes three inquiry subsections: scientific inquiry; inquiry learning; and inquiry teaching, explaining that if it is central to science learning then it must be central to teaching as well. This statement makes clear that there are three different subjects that can perform inquiry activities: scientists, the students and teachers.

In the last fifty years scientific inquiry has been a topic of interest in educational research mainly with the student as the principal subject but, according to Mac Neil and Krajcik (2008), there is a little amount of researches on the teachers' practices in inquiry classrooms. This research aimed to characterize Scientific Inquiry practices of workshop experts for elementary students in Mexico in a teaching-learning science programme.

THE ROLE OF THE TEACHER IN THE SCIENCE INQUIRY CLASSROOM

> A teacher, in order to guide an inquiry lesson must develop a robust capacity for pedagogical design, and the ability to put into practice a variety of personal and curricular resources to promote student learning. In Scientific Inquiry, the teacher´s role becomes less involved with direct teaching and more involved with modelling, guiding, facilitating, and continually assessing a collaborative student work. (NSF, 1999:82)

In an inquiry based teaching and learning the student and the teacher are expected to develop certain abilities related in each level to learning and teaching. The National Science Foundation (1999) adapted, form materials created by the Exploratorium institute for inquiry (2010), three different inquiry guides that look special characteristics in the classroom

1. What are the students doing? On-the-run reference guide to the nature of elementary science;
2. What is the teacher doing? The role of the teacher in the inquiry classroom;
3. How does the environment support inquiry? The social and emotional environment of the inquiry classroom.

Each one of them has an average of five activities and each activity present no less than three indicators.

The programme selected to performed this research is PAUTA (Programme Adopt a Talent: "*Programa Adopta Un TAlento*") created by the Mexican Academy of Sciences, in collaboration with the National Autonomous University of Mexico. This programme provides scholar science and mathematics workshops directed to children that are studying in elementary schools. In PAUTA there are Workshop Experts whose role is to head the workshops with students.

The programme, in a constructivist learning and teaching approach, pursues that children explore and analyse different phenomena by means of activities (Garcia *et al*, 2010), specifically designed to learn science by developing their scientific abilities. The activities, as was recommended by Schwab (1960), are arranged in sequences of the experimental type that allow students to review the concepts involved in a specific problem or question on different contexts.

Each activity has a document "expert workshop guide" with specific suggestions of actions and instructions that the teacher must perform to promote the children's development of science abilities in an inquiry activity context. According Martin-Hansen (2002) categories of inquiry, this is guided inquiry, in which the question to be solved is presented by the teacher and the student may decide how to approach it.

METHODS

Taking in account that the activities developed by the workshop experts are crucial tools with which teachers engage students in science as inquiry (Forbes & Davies, 2010) and by extension the pedagogical activities involved, the activity called "Floating and sinking" was selected to be examined; in this activity the children analyse how different objects can or cannot float.

The data collection was made primarily by videotaping the activity sessions of four workshop experts, in two main phases: the first semesters of 2008 and 2010. This four workshop experts were selected based on a previous research that aimed to document the Pedagogical Content Knowledge of the experts with a Content Representation frame of Loughran *et al.* (2004) that was applied all of the nine workshop experts. The selection of these four experts was made taking the next bases: That they wave participated in the previous research, the permanence in the programme, and finally the bachelor speciality: one was mathematic, one ethnology and two biologists.

The selection of the data collection corresponds to the two implementation of the same workshop, with the same four workshop experts, with students (from 6 to 13 years old) in the first year in the programme. It is important to mention that the programme have groups of student arranged by the levels that they have taken in the programme rather than the age that they have. The first time "Floating and sinking" took place was in 2008 and the next implementation with these characteristics was until 2010.

One video camera was used to film the actions of the workshop expert, and since two of them conducted each session, audio records were made for each one. For the analysis, the videotapes were coded with the indicators related to the activities in each one of the guides to observe inquiry activities. The present results have more emphasis on the analysis of the workshop experts' inquiry indicators.

RESULTS

We have found significant differences between the two periods (2008 and 2010). Regarding to the "Teachers Model Behaviors and Skills", in the 2010 workshop experts posse more scenarios to enhance that the student take control and responsibility on their action, whereas in the 2008 workshop experts did not promote this actions.

A clear evolution in the 2008 and the 2010 were fund related to "Teachers Use Multiple Means of Assessment" and "Teachers Act as Facilitators", mainly the workshop experts in 2010 listen more often and talk or direct much less to the student, the conversation held in the classroom in 2010 evidence that the Expert is listening carefully to the children and using that as basic information to express the next idea or comment only if necessary.

> 2010 Student 1: We weight the wooden cylinder, the wooden cylinder floats but it was lighter. And the spoon, [the metal spoon] well the spoon is lighter than the cylinder. But, the cylinder is…well…
> Workshop expert: ¿Which cylinder? [The metal one or the wooden one]
> Student 2: The metal spoon is heavier; it is one gram heavier than the wooden cylinder
> Student 1: But the cylinder was heavier, was not it? Or was it? [Student2 y Student3 confirm that the cylinder was heavier]
> The cylinder was heavier than the spoon, it [the cylinder] did not sink and the spoon did.
> Workshop expert: What can you say about this?

> Student 1: Well, I think it is the material.

Whereas in 2008 there are several interactions that clearly show that the expert did no listen to the student, that they try to impose a particular question that is different than the actual interest of the students, and that they show up to student discussion an posse a new question, before listening to what they have been arguing.

> 2008 Workshop expert: Which one of the objects that you have is going to sink?
> Student 1: The iron one
> Workshop expert: that is right the metal cylinder
> Workshop expert: Which other?
> Workshop expert: over here they said that the wooden cylinder. Why do you believe that this one is going to sink? It is because it is heavy, right?

Also the Workshop Experts in 2010 started to suggest new things to look at and try, and encourage further experimentation and thinking in their students but in 2008 they followed the facilitator guide in a more rigid way.

CONCLUSIONS AND IMPLICATIONS

This research shows that the Workshop Experts have evolved in their behaviour and actions, from a more participant and directive approach to an assessing and guiding role that involved listening and observing the student actions and interaction. In this guiding role they suggest more often new things to look at and try, and thinking: This could be related to the novelty of the activities and the use of inquiry based activities in 2008 and to the expertise gained though the coupled of year in the programme. It seem that with time, more formation and experience immersed in an inquiry programme, inquiry actions can be performed by teacher with more emphasis and probably with more clarity on the goal pursued in each one.

The workshops experts aided with inquiry lesson materials and their regular formation courses can produce a learning context that can be categorized by the indicators as Inquiry based teaching and learning.

As a corollary all changes involved a considerable amount of energy, work and commitment; specially changing the pedagogical skills, but building them is equally important to the construction of content knowledge, particularly as a means of providing student-centred learning experiences.

And in a metacognitive level, to improve the science teaching-learning process, it is important to document what happened in an actual Workshop, how Workshop Experts establish didactic units with these characteristics, and how they promote the development of scientific abilities in their students.

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EPISTEMIC STYLES OF THINKING OF PRE-SERVICE CHEMISTRY AND PHYSICS TEACHERS

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Abstract: Theoretical works of different authors lead to the assumption that the subject of study influences the epistemological stances of students. Regarding pre-service teachers, views on aspects of Nature of Science can differ between biology, physics, and chemistry teachers. Due to the lack of quantitative instruments examining epistemological stances in respect of scientific realism, a questionnaire was developed and carried out in a pilot study to pre-service secondary physics and chemistry teachers in a pilot study (students and Ph.D. students; n = 41).

The results of the pilot study are insightful. The chosen items are comprehensible and show a good reliability. The size of the sample admits of item response theory (IRT) calibration, showing the items fit the model adequately. As a first result, the difference of the degree of scientific realism of pre-service chemistry and physics teachers is significant and the effect size is huge. Chemistry teachers tend more to scientific realism than physics teachers. The degree of scientific realism scale might be useful for explaining the classroom handling with models and modelling of science teachers by epistemological positions.

Keywords: Nature of Science, Philosophy of Science, Secondary Teacher Education, Chemistry, Physics

THEORETICAL FRAMEWORK

In the past decades philosophers of science have argued whether or not philosophical stances of scientists influence their work (see McMullin, 1984, Scerri, 2000; Elfin *et al*., 1999). Additionally, the relationship between specific subjects and epistemic positions has not yet been pointed out. But despite this lack of quantitative research one can find some evidence for different 'styles of thinking' in the history of science. This concept was first developed in the early 20th century by Ludwig Fleck and continued by Alistair Crombie and Ian Hacking (see Bensaude-Vincent, 2009). Bensaude-Vincent used the term 'styles of thinking' for an analysis of the chemists' approach to science. In a similar way Eisvogel (1994) examined the character of a theory as either 'realistic' or 'instrumentalistic'. These characters form the thinking among the community of scientists using these theories.

Independent of the question whether there is an impact of philosophical stances on applied scientists' thinking and acting, there is much more interest for research in science education regarding the relationship of epistemology of science teachers and their handling of models and students' beliefs in educational situations.

In spite of increasing calls to implement Nature of Science (NoS) in the science curricula (Lederman *et al.*, 2002), quantitative studies to point out science teachers' epistemic stances and their influence on aspect of pedagogical content knowledge (PCK) have not yet been carried out.

The first criticism on stated NoS-tenets in science education was given by Alters (1997), examining the difficulties of philosophers and scientists with the goals of NoS-programs.

Although there was a dispute about the design of Alters' survey, the criticism on stated tenets cannot be overlooked: philosophy does not give absolute and final answers. In contrast Lederman et al. (2002) argued for the emergence of consensus on the tenets with increasing the level of generality. This position can also be found in earlier works, like Abd-El-Khalick et al. (1998). But following up the path of generality regarding epistemic assumptions leads to the meta-level of objectivity and subjectivity of science, or–in general parlance–to the question whether an objective and independent outer world exists or not. Basic assumptions determine the stances in the lower levels, e.g. one cannot be sure about the factual existence of non-observable entities without claiming a world independent of the observer.

To respect the different views on the world it is necessary to change the tenets into open questions, which was first suggested by Clough. For instance, instead of teaching the tenet "scientific knowledge is tentative" one should rather discuss with the students the question "in what sense is scientific knowledge tentative?" (Clough, 2007).

This study is concerned with the question whether or not the styles of thinking of chemistry and physics student differ in respect of the degree of scientific realism. It is supposed that a more anti-realistic epistemic position of student teachers regarding the reference of scientific theories and entities allows them easily to switch between students preconceptions driven by common-sense-realism and mature scientific concepts.

Due to some evidence from the literature (e.g. Scerri, 2000; Bensaude-Vincent, 2009), it is expected that the more anti-realistic stances will be found within the physics teachers group, while the chemistry teachers share a more realistic view on the world.

METHODS

To examine the epistemological positions of chemistry and physics student teachers a questionnaire was developed and carried out in a pilot study to measure the degree of scientific realism. The theoretical framework for the categorisation of the different thinking styles was based on philosophy of science literature (Hacking, 1983; Van Fraassen, 1980; Putnam, 1975).

The idea of a 'degree of scientific realism' scale bases on the assumption, that each position in philosophy of science has its own authority, but all positions share a more or less realistic approach. The aim of the questionnaire is to examine a one-dimensional scale to describe the degree of scientific realism of science teachers.

20 statements about scientific realism or anti-realism were collected from philosophy of science literature, followed by a translation into non-philosophical language. Pilot study participants' agreement regarding the given statements was measured by a four-step Likert-type scale from "I totally agree" to "I totally disagree". The statements derived from philosophy of science literature were verified in terms of the comprehensibility through the participants' option to leave the item out, if they did not understand the arguments' meaning.

RESULTS

The pilot study was conducted with a sample of 41 pre-service chemistry and physics teachers, 20 student teachers at the end of their study and 21 Ph.D. students of science education. The respondents' demographic data is presented in table 1.

Table 1: Respondents' demographic data.

Variable		Sample Size
Total		41
Level of education	*Students*	21
	Ph.D. students	20
Subject of study	*Chemistry*	23
	Physics	18
Sex	*Female*	18
	Male	23

Following Linacre (1994) the sample size suffices for partial credit model (PCM) item calibration, which was made with R-statistics. The analysis examined a mean item-infit-MNSQ of 0.99 (S.D.: 0.25; range: 0.56–1.43) and a mean item-outfit-MNSQ of 1.04 (S.D.: 0.26; range: 0.56–1.50). The values show the productivity for measurement (Linacre, 2002). The PCM item measures are sufficiently distributed with mean modelled standard errors of 0.21 (S.D.: 0.02). The items' difficulty spread is between −1.81 and 1.19 logits, the spread of respondents' measures spans from −2.24 to 0.85 logits on the person–item map. In the further analysis the PCM measures will be used instead of the persons' raw scores.

A Shapiro-Wilk test (Shapiro & Wilk, 1965) verifies the participants' measures come from a normally distributed population. The thesis of a non-normal distribution is refused ($p = 0.45$). Further tests including subgroups “physics” and “chemistry” show quite similar results ($0.42 < p < 0.49$).

One major finding is the significant difference in the degree of scientific realism between the subgroups of pre-service chemistry and physics teachers (table 2). The effect size of the difference is huge (Cohen's $d = 1.24$).

Table 2: Degree of scientific realism mean measures of pre-service chemistry and physics teachers.

Subject of study	Measure	S.D.	T	p-value
Chemistry	0.13	0.68	3.90	< 0.01
Physics	-0.80	0.81		

CONCLUSION & IMPLICATIONS

There has not been collected enough data yet for verified conclusions. Nevertheless, if Nature of Science should be part of science education, one has to rethink teachers' education in respect to the philosophy of science. The very creating of new chapters for textbooks and enlarging or substituting of curricula is not an adequate form of implementing the philosophical area of Nature of Science in secondary school education. The development of a deeper understanding of the philosophical debate might be a key skill for science teachers in respect of analysing and understanding students' misconceptions. To answer this question, the questionnaire will be used with a larger sample, combined with quantitative instruments to measure the use of models in classroom contexts.

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NOS IDEAS AS CNTEXTUALIZED IN THE PRESENT SCIENCE: NANOMODELLING AS AN EXAMPLE

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Abstract: Understanding nature of science (NOS) is widely considered an important educational objective and views of NOS are closely linked to science teaching and learning. Nowadays, there is a kind of consensus about the content of NOS teaching, which is a result of analyses in educational, philosophical, sociological and historical research. This consensus content is listed as statements of science, which students are supposed to understand during their education. Research in science education has anyway frequently shown that students have not reached sufficient understanding about NOS. The reason is proposed to be that the formal statements about nature of science and scientific knowledge can really be understood only as contextualized in the practices of science. To contextualize NOS statements in the actual practices of science in contemporary education, we need empirical studies, which are performed in co-operation with scientists themselves. This is such a study; by employing both a questionnaire and interview as research methods this study reveals how practicing nanoscientists perceive the nature of science developed in their own research projects. Many of the general NOS statements arise as contextualized in discussion with practicing scientists; deepening thereby our understanding about the core of NOS, science and scientific knowledge, for science education. The results can be used also as such, as a basis of reflective stories of recent science for contextualized NOS teaching – and the method developed can be used as a basis of "interview a scientist" tasks and in further research. For the contextualized NOS education suggested in this paper, we would need several similar empirical studies.

Keywords: contextualized NOS, NOS education, scientific modeling, contextualized interview study

NOS CAN BE UNDERSTOOD AS CONTEXTUALIZED IN EXAMPLES OF SCIENTIFIC RESEARCH

Developing an adequate understanding regarding the nature of science (NOS) in students has been widely seen at the core of the scientific literacy (Matthews 1998, McComas & Olson 1998). Indeed, understanding the nature and the basis of what one is studying encompasses coherent conceptualization and conceptual understanding (Osborne et al. 2003, Sandoval 2005) – the traditionally valued goal of science education. Understanding about science and its nature increases then one's interest in science and science classes. At the moment, there is a kind of consensus on what the NOS understanding does include; this is a result of analyses of educational, philosophical, sociological and historical research and discussion (Lederman et al. 2002, Mathews 1998, McComas & Olson 1998, Osborne et al. 2003). Such NOS content is defined by listing statements of nature of science, which students are supposed to learn during their education – or as family resemblances (Irzik & Nola 2010). Because science is rich and dynamic endeavour and scientific disciplines are quite varied, the NOS statements are quite general descriptions about "science". For example, the statements "models and modelling have important roles in science" and "science has an impact on technology and technology has a role in science" appear frequently on the lists of NOS statements. These general NOS statements can be interpreted in a numerous ways: for example, the viewpoints guiding scientists' research practices is the viewpoint supporting their concept building and the understanding about the scientific process.

Irrespective of the century-long history of the place of NOS in many curricula (Lederman et al. 2002, McComas & Olson 1998, Mathews 1998), the NOS objectives – learning the NOS statements for understanding – have not been reached (see e.g. Clough 2011, Lederman et al. 2002, McComas & Olson 1998, Osborne et al. 2003 and the references therein).The situation is considered to be the result of the taken-for-granted explicit and abstract view towards NOS (Lederman et al. 2002, Sandoval 2005). One can understand the abstract NOS themes only as contextualized into different contexts of scientific research; but students do not know what scientists do while working. Thus, students have to become familiar with authentic examples of scientific research, which provides them with contexts to understand the abstract NOS themes. Research indicates that by this kind of reflective – or contextualized – approach to NOS education, good results can be reached (Clough 2011, Hanuscin, Akerson & Phillipson-Mower 2006, Matthews 1998, Sandoval 2005). Moreover, when opening this kind an insight to the production of scientific knowledge, NOS teaching increases the coherence of science education. Thus, what is needed to enhance NOS understanding in science education is concretizing by examples what the NOS statements mean in the practices of science in different fields of research.

At the moment there are rich examples of contextualization in historical stories of science (e.g. Clough 2011). This study suggests that in order to support understanding about the present science for literacy, which means an ability to apply one's NOS understanding in public discussion about contemporary science, also examples of what does NOS ideas mean in the context of contemporary science need to be addressed. Discussing the present science in science classes may also increase students' motivation to study NOS and science in general. Anyway there is a lack of empirical studies about the nature of science in the contemporary knowledge construction practices of science and scientists' ideas about the nature of science they do. Thus, here is provided such an empirical study, as an exemplary case, a study about the nature of science as seen through the practices of nanoscience. The study examined how the viewpoints opened by NOS statements to scientific knowledge construction and justification may do appear in the nanoscientists' views. The contextualized method was developed and employed in order to increase the validity: simple, the scientists were not asked what nice ideas they would like to be told in education about the nature of their field, but instead to encourage them to tell about the nature of their field at the practical level. Thus, the study provides exemplary cases, by which to understand the NOS themes in the practices of science. The abstract NOS ideas can be better understood by listening to such exemplary voices in the mixed choir of scientists.

NOS LISTS AND DIFFERENT METHODS OF SCIENCE

The nature of science is in the lists of NOS ideas defined from the viewpoint, how natural science differs from the humanities, for example: thus, the general definitions of science, such as listed by Merton norms (objectivity etc.) or counter-norms, are not listed. The table 1 presents a summary of the typical NOS ideas appearing on NOS lists, as it was summarized on basis of previous comparisons and studies (Hanuscin, Akerson & Phillipson-Mower 2006, Lederman et al. 2002, McComas & Olson 1998, Osborne et al. 2003, Sandoval 2005).

- *"science is an attempt to explain natural phenomena"*
- *"there is no one scientific method", but "a variety of scientific methods is employed"*
- *"models and modelling have important roles in science"*
- *"science has an impact on technology and technology has a role in science"*
- *"the creative role of human beings, societies and cultures in constructing science"*
- *"the historical development of science"*
- *"the impact of science on cultures and societies"*
- *"science is essentially a global phenomenon having both global and local influence"*
- *"certainty or tentativity of scientific knowledge"*
- *"theory-ladenness of experimentation"*

Fig1: *A list of the typical NOS objectives*

The natural sciences become first and foremost defined by the objectives adopted and methods employed: The shared motive of the different natural scientists is an attempt to explain "natural" phenomena (NOS theme) taking place in natural and man-made environments. In that is used a variety of methods (NOS theme). Indeed, the nature of scientists' knowledge building and the nature of the knowledge produced in that are strongly figured out by the methods used. The methodologies employed in revealing reality can be divided into theoreticians', modellers' and experimenters' fields of business; the different practitioners' can see the nature of science in a quite similar way but they explain the nature of this enterprise from different viewpoints. In science studies, most analysed are the theoreticians' viewpoints and the viewpoints opened by theory-oriented approaches. For about a half decade attention has been increasingly paid also on experimentation and experimenters' viewpoints (see Tala 2009 and references therein). Only recently, when modelling is noticed to be rapidly growing, as the third method of science beside the traditional ones, there has been a growing interest toward it in science studies (e.g. Humphreys 2004, Morrison and Morgan 1999). Then has been noticed also the lack of empirical studies considering the practices of modelling and viewpoints opened by practising modellers. Because modelling is nowadays widely used by side of the traditional methods, modelling will probably be soon described by more details also in the lists of NOS statements (like the traditional methods are in the present lists).

In science education models are typically seen as deduced from theories and modelling as a direct continuation of theorizing, which reflects the situation in the science studies couple of decades ago. The discussion about models in science studies during the last decades in science studies, has given them a variety of roles, but it have been generally agreed that models are representations (see e.g., Giere 2004, Hughes 1997, Morrison and Morgan 1999): we gain knowledge from models because they represent target objects in the world in some relevant respects. Moreover, recent studies (e.g., Galison 1997, Hacking 1983, Humphreys 2004, Morrison & Morgan 1999) indicate that the perspective on the practices of science provides a different approach to models and modelling; models and modelling have been suggested to have quite an independent role as mediators between different methods (e.g. Morrison & Morgan 1999). These questions of how the relations between reality and the different methods employed are constructed are important for scientists (Hacking 1983; Galison 1997) – and it is important for science education as a base of the knowledge taught. Thus, in order to understand better the nature of this enterprise called science, it is worth for to ask also practising scientists how those links with reality – or realities – and different methods are constructed in their knowledge building

METHODS: QUESTIONNAIRE AND INTERVIEWS AS CONTEXTUALIZED IN THE INTERVIEWERS' PROJECTS

The phenomenological case study (Tala 2011) taken here as an example, discovers the conceptions and beliefs of nature of science guiding the knowledge building practices of nanoscientists – and teaching these practices in their doctoral education. The informants are Finnish material physicists studying nanophenomena by realistic simulations, 5 experts (E) and 5 apprentices (PhDs; A). The research was planned in co-operation between researchers' in science education, in physics and in philosophy. To get a broader view, the views of the informants were studied by multidimensional methods: The informants answered a written questionnaire about their epistemological and methodological views as contextualized in their on-going projects. The questionnaire was planned on basis of understanding opened by recent science studies and familiarity with the practices of physics – this basis also helped in contextualizing the study in the interviewers' research projects.

The NOS views are many time tested by asking scientists questions at general level, asking such questions as "what you think are the most important points every citizen should know about the nature of science?" or "do you think models play a role in science"? Anyway, many physicists do not like to speak "philosophically": although they deal with contextualized philosophical questions in their work, they do not need to think the philosophical question at the general, explicit level while working. Indeed, there is always a possibility that the interviewer and the interviewee understood the general terms in different ways. Moreover, when the questions or answers are contextualized in the informants' concrete doings, in this case in their on-going research projects, they may tell what really guides their action and decision making, rather than what theoretical lessons they may have learned about it, for example.

The informants were interviewed one by one; the interviews were semi-structured on the basis of the interviewees' responses to the questionnaire and their articles they sent in advance. It was noticed that the same viewpoints emerged over and over again in the responses of the internationally successful scientists, increasing the reliability of the results. The transcript interviews together with the responses to the questionnaire were analyzed by qualitative content analysis: the NOS statements formed the categories used and then also the links existing between the contextualized NOS statements were noticed. The interviewees checked the analysis; as a consequence, the interpretations became corrected according to the interviewers' requests (validity).

RESULTS: NOS AS ONTEXTUALIZED THROUGH THE VIEWS OF PRACTISING MODELERS

Many of the shared NOS ideas arise in the interviews with practicing nanomodellers, as contextualized in their projects (particular definitions of NOS). This kind of contextual approach also clarifies how the NOS statements are closely connected to each others in authentic research processes, which will be seen in the following examples picked out from the results. Every field of science highlight and explain more some NOS ideas than others. Because the modellers' views are under scrutiny in the following, the statements 'science has an impact on technology and technology has a role in science' and 'models and modelling have important roles in science' become naturally emphasized.

Basically, the expert nanomodellers define their field of research to be "application-motivated basic research" (E1), which they explained means that possible applications – potential technological, financial and human needs – make selections between the possible research projects before launching one. They do not develop commercial nano-products[1], but for financial reasons, for example, those interesting research topics are selected, which have "relevance of some practice" (E1). In particularly an apprentice reasoned his research by "tree words: nano, bio, medi" (A1). The interviews told that they clearly refer to the applications, when writing the applications for financial funding or introductory parts of their publications or telling about their research for general public. At the same time nanoapplications, impose new ethical problems – for example, the interactions of nanoparticles in a human body, are not known yet – and become limited on this basis. Nevertheless, the interviewers highlighted that the applications "are [only] in the back of my mind" (E2) and thus they consider that they do not need to consider the ethical questions related to the possible applications. Thus this strive for applications contextualizes in a way not only the NOS statement 'science has an impact on technology' but also the pair of NOS statements 'science is a product of a large social and cultural settings' and 'science has an impact on cultures and societies'.

Furthermore, technology provides an access to the artefactual nanoworld: when working, modellers sit mostly by their computers. No one of the interviewers failed to mention how computational and technological abilities, namely the capability of computers figures out what can be studied by nanomodelling, and how. The fundamental reason is concentrated in the following novice's response: "the whole of molecular dynamics [the favoured method] would not function if the frequently repeated calculations were not made as simple as possible and quick for the computer to calculate" (A2). As a consequence, what can be studied and how it is studied in nanophysics is strongly figured out by technological limits, namely by the capability of computers. Nowadays, the length of the objects simulated at the nanolevel has to be limited to some nanometers, or, alternatively, an event on the surface seen by a nagged eye can typically be simulated only for a nanosecond. Nanoscientists are creative (NOS theme) when discovering the nanoworld within these limitations of time and length scale.

But the modelling technology, and especially computational power, is a rapidly developing field, advanced as collaboration between scientists and technologists. A century ago, nanoscientists did not have the kind of inside to the reality of physics they develop and maintain nowadays. The development is not going to stop here; with a great pleasure, the interviewees described what they can study in the nanoworld, when computers develop on. In this way, also the NOS theme 'the historical development of scientific knowledge', is easier to understand by considering a concrete development of technological capability.

As a new field of study, nanoscience is a rich example of how science develops by correcting and extending the previously "known" and the scope of this knowledge: at the time, when the most of the basic scientific content presented in the high school text books where discovered, the nanoworld was entirely unexplored.[2] In due to the dreams of the future development, in

[1] The applications of nanotechnoscience, ranging from smart drugs to environmental materials with extraordinary properties and to fast processing, ultra thin, flexible machines (see also, Rosei 2004), improve many ordinary artefacts.

[2] The recent history explains also the contemporary science: For example, scientists did not have access to the nanoworld and nanophenomena before the invention of the scanning tunnelling microscope by Gerd Binnig and Heinrich Rohrer at IBM Zurich Research Laboratory, for which they received the Nobel prize in physics in 1986. The scanning tunnelling microscope is an instrument for imaging surfaces at the atomic level, which is nowadays an everyday device in laboratories, it is employed also by those interviewers who have experience of working on the experimental side of the field. Additionally, the discovery of fullerenes in 1985 by Harry Kroto, Richard Smalley, and Robert Curl (Nobel prize in chemistry) was important for the foundation of nanoscientific research.

addition to the development of computers' calculation power allowing the increase in the size and time of the simulations, the modellers mentioned also their expectations concerning the development of experimental technology: according to a novice, at best this would mean the "real-time measuring equipment"(A3) (like a video camera). At the moment they observe the situation like in-direct still photos and numbers linked to those. But then, "these models are naturally quite simple, and thus do not represent a system very well"(A2). The more advanced a interviewed scientist is the more (s)he seems to highlight the role of technology figuring out the scientific modelling. Then an expert pointed out: "when a physical template [the mathematical formulation of physical law] is fitted to a computer, it becomes a kind of new theory...[it] is never the same as the original physical template which provided the starting point."(E3) In consequence, the NOS idea 'science has an impact on technology and technology has a role in science' is quite a deep one: the science-technology relationship should be understood to strongly figure out both activities to the extend it alters the basis of knowing in both fields, the epistemologies employed. Finally, even the interviewers' modelling is called "the realistic modelling", such successful modelling is guided by an instrumental view towards models and modelling, as seen in the following.

In nanomodelling is generated new knowledge of the previously unknown phenomena under limited possibility for experimentation: this is generative modelling. In practice the modellers make a coarse model, which then become fitted with experimentation. In that fitting, modelling figures out the experimentation from the planning of the experimental settings to the interpretation of them. But then it is a two-way process: also modelling becomes fitted to experimentation, and validated by this fitting with experimentation. This is what the NOS statements 'the empirical base of science' and 'experimentation is theory-laden' mean in the case of the practices of nanophysics. Nevertheless, even the development of modelling and experimentation take place in close interaction, those remain as separate approaches. The modellers emphasize this to the extent that "a model doesn't care about the actual conditions or claims that it explains them, since the only important property of a model is its functionality"(A4). In consequence, the modelling, which mediates between theory and experimentation, advance both limited traditional methods, experimentation and theorizing, staying anyway an independent approach.

It was notices in this study that young scientists adopt these above introduced contextualized views about NOS in their field during their education. For example, young modellers start to understand, how technology both enables and limits research projects, and how it figures out the scientific knowledge construction and justification processes. The results indicate that the longer a successful young modeller has worked for a research group, the nearer her/his contextualized NOS view are the elder researchers' views. Thus, the view opened by this empirical study seems to reflect the view, which guides scientists in successful knowledge building. As such, it deepens our views about the nature of science, by the viewpoints supporting conceptual understanding and understanding about the scientific process.

CONCLUSIONS AND IMPLICATIONS

This study showed how many of the general NOS notions arise as contextualized in discussion with practicing scientists. Understanding the practitioners' contextualized NOS views deepens our view to science for science education. Especially, the results of this empirical study extend recent views of the quickly developing nature and roles of modelling, simulation and modelling technology in science – and theirs relation to experimentation and theories. In science classes the understanding of the nature of science listed as NOS statements, can be improved by providing examples of contemporary science, constructed on the basis of *empirical studies* like this.

The empirical base provided by the study on nanomodellers' views can be used as such, for example, as picking up case stories from the data, providing concrete meaning into the abstract and general NOS notions in science education. Because the study was contextualized in the interviewers' research projects, there in the interview data exist many practical examples of the kind of knowledge building described here and, because those are in the field of realistic modelling, many of them could be introduced also at the level of compulsory education as examples of this kind of way of thinking. In order to make NOS teaching by contextualization effective, the stories and their relation to the school science activities have to be also discussed in science classes; good learning results have been reached by reflective approaches to NOS, and by approaches combining the implicit and explicit NOS teaching (Hanuscin, Akerson & Phillipson-Mower 2006, Sandoval 2005). Indeed, different fields of science highlight different viewpoints to the nature of science. In order to extend the base of examples in contemporary science, we need more empirical studies performed on different fields of science.

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TEACHERS' CONCEPTIONS ON NATURE OF SCIENCE: STRENGTHS, WEAKNESSES AND INFLUENCE OF TEACHING PRACTICE

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Abstract: The understanding of the nature of science (NoS) is assessed in a large sample of high-school science teachers, which encompasses pre-service and in-service teachers. The teachers anonymously completed 15 questions, whose responses are scaled into a set of attitudinal indices. The results show global neutral attitudes of teachers, and the detailed examination of indices identifies the teachers' strengths and weaknesses beliefs; unlike other studies, which provide a negative profile of teacher understanding, the diagnosis that emerges is more complex, as appropriate beliefs coexist with some inappropriate beliefs; however, the overall assessment must be negative, because the science teachers should exhibit better understanding of these issues. The pre-service science teachers do not significantly differ from in-service science teachers, so the evidence is not decisive to claim that science teaching practice contributes to improve NoS understanding. These results suggest the urgent need to update initial and in-service training for science teachers, to improve their understanding of NoS topics in science curricula, and thus improve science teaching. The implications of the methodology and results for the research, teacher training, and teaching of nature of science and technology issues are discussed.

Keywords: nature of science, science-technology-society, evaluation of conceptions, teachers' thinking, teacher training.

BACKGROUND, FRAMEWORK, AND PURPOSE

The nature of science (NoS) is widely accepted today as an undisputable target of science education to achieve an authentic scientific and technological literacy for all. Understanding NoS is deemed the most innovative goal of science education and an important component of scientific literacy for all. Thus, the school science curriculum should incorporate and the teachers should teach them (e.g., Abd-El-Khalick & Lederman, 2000; Lederman, 1992).

Research on NoS consistently reports that pre-service and in-service science teachers' understanding of NoS issues widely deviate from the modern views of science, as the history, philosophy, and sociology of science and technology studies have currently set up. Rather it seems close to traditional, positivist (logical empiricist), and idealistic views of S&T, which are similar to the list of myths (McComas, 1996), or contrary to the list of consensuses (Bartholomew, Osborne & Ratcliffe, 2004). Many of the research show that teachers understand science as a static body of knowledge (thus, true and unchangeable), or as a process of discovering what is out there, not as a human process of inventing explanations, and so on (among others, see a recent revision of state of art in Lederman, 2007).

Teachers' NoS beliefs are central for science education, because they decisively influence their teaching practices within the classrooms. For instance, teachers who belief that science is an accumulation of knowledge tend to do experiments by following the textbook instructions and getting the right answers; in contrast, teachers who belief that science changes are more likely to encourage students' discussions (Smith & Scharmann, 1999). Besides, some studies pointed out that teachers with adequate NoS understanding do not automatically and necessarily teach NoS issues into classroom (Lederman, 2007). Although there are many factors involved in the decisions to teach NoS, in general, teachers lack relevant pedagogical skills to this aim. Further, research points out that some teaching practices are key to adequately address curriculum NoS issues: planning, designing and assessing the NoS contents, supply explicit adequate NoS concepts to learners, and providing general reflection and coherence between NoS tenets and the representations of science and technology within the classroom (Lederman, 2007).

RATIONALE

Scarce research on teachers' conceptions about NoS has been focused on non-Anglo, in-service teachers until recently. So this paper draws data from an international cooperative investigation (Iberian-American Project of Evaluation of Attitudes Related to Science, Technology and Society, Spanish acronym PIEARCTS) that diagnose the NoS beliefs across seven Iberian-American Spanish and Portuguese-speaking countries. This paper presents the results of the application of the new PIEARCTS methodology to assess the NoS conceptions of large teacher sample that include pre-service and in-service high-school science teachers. The NoS conceptions are posed here from a wide perspective that includes internal aspects of science (philosophy and sociology of science) and external aspects of science (relationships of science with technology and society). The paper search empirical answers to the questions: Which are the strengths and weaknesses of teachers thinking on NoS? Do practitioner science teachers' understand NoS better or worst than their pre-service counterpart?

METHODS

Sample

The participants are 613 high-school science teachers, about one third (32%) in-service teachers and two third (68%) pre-service teachers. pre-service teachers in Spain are university graduate students in STEM specialties (physics, chemistry, biology…), who are involved in a postgraduate diploma in science education to be credited as prospective teachers (without educational experience); the in-service teachers are practitioner teachers. Their age range from 23 to 63 years and the sample splits approximately in equal halves by sex (52% men).

Instrument

The Questionnaire of Opinions on Science, Technology and Society (Spanish acronym, COCTS) is an adaptation into Spanish language and culture of the VOSTS and TBA-STS (Aikenhead & Ryan, 1992; Rubba, Schoneweg & Harkness, 1996). The COCTS is an empirically developed pool of 100 multiple-choice items, which inherits the credit of VOSTS and TBA-STS, as one of the best paper and pencil instruments to evaluate NoS&T beliefs (the empirical development of items warrants the item validity). All items display a common format: the stem presents a specific NoS issue, using a non-technical, familiar and simple language. A changeable number of sentences, each labelled with a letter A, B, C…, follow the stem; each sentence states a rationale position (belief) on the stem issue (Vázquez, Manassero & Acevedo, 2006).

The research team consensually selected 30 items that were distributed into two 15-item paper and pencil research booklets (F1 and F2; see table below), which meet a balanced coverage of the different issues. Each participant answered one randomly assigned form (F1 or F2), with roughly a half of the participants answering the Form 1 (309), and the Form 2 (304).

Table 1. Labels of the questions included in the two questionnaire forms (Form 1 and Form 2) across the structural dimensions of NoS issues. A short description of the question issue follows each key number.

Dimensions	Form 1 Items (key / issue)	Form 2 Items (key / issue)
a) Definition of S&T	F1_10111 science	F2_10211 technology
	F1_10411 interdependence	F2_10421 interdependence quality of life
b) STS Interactions	F1_30111 STS interaction	
Influence of society in S&T	F1_20141 country's government policies	F2_20211 industry
	F1_20411 ethics	F2_20511 educational institutions
Influence of S&T in society	F1_40161 social responsibility contamination	F2_40131 social responsibility information
	F1_40221 moral decisions	F2_40211 social decisions
	F1_40531 life welfare	F2_40421 Application to daily life
		F2_50111 union two cultures
Internal Sociology of science	F1_60111 motivations	F2_60521 gender equity
	F1_60611 women under representation	F2_70211 scientific decisions
	F1_70231 consensus decisions	F2_70711 national influences
	F1_80131 advantages for society	
c) Epistemology	F1_90211 scientific models	F2_90111 observations
	F1_90411 tentativeness	F2_90311 classification schemes
	F1_90621 scientific method	F2_90521 role of assumptions
		F2_91011 epistemological status

Procedures

The respondents rate their agreement (1, total disagreement; 9, total agreement) on each sentence of the items. These sentence scores are scaled into quantitative indices (-1, +1), whose meaning is invariant across all sentences: the higher (lower) the index score, the higher (lower) the belief's correctness according to the current knowledge from history, philosophy and sociology of S&T (Vázquez & Manassero, 1999; Vázquez et al. 2006). Averaging the sentence indices within each item, four new indices are produced: three indices for the three groups of sentences (categories) and one global index for the whole item. Thus, this scheme describes the teacher's through on NoS through over one hundred and fifty invariant indices (sentence, category and item indices). The index scores allow the use of inferential statistics for hypothesis testing, which can be applied to compare groups (pre-service vs. in-service teachers), or to set up cutting points for identifying the strengths (highest positive), weaknesses (lowest negative), and neutral beliefs (Vázquez, Manassero & Acevedo, 2006). The criteria to achieve relevance are the statistical significance ($p < .001$), and the effect size of the differences (differences measured in standard deviation units; $d > .30$).

RESULTS

The diagnostic methodology evaluates each item through a set of variables that includes the sentence indices, the three category average indices, and the overall item index (average of the three categories). The grand mean of the item indices for all teacher sample are slightly different for the form 1 (m =.1862; DE = .5456) and for the form 2 (m = .0809; DE = .5531); both are positive, but quite close to the null value. This result can be interpreted as a indicating neutral though somewhat positive conceptions towards NoS issues; some positive indices compensate the negative ones to produce this approximately neutral value for the global mean of the entire sample, which suggests that informed beliefs coexist with other less informed beliefs.

Teachers’ strengths and weaknesses

The distribution of the average item indices is displayed in figure 1 and 2 for both forms (F1 and F2). Both figures show asymmetrical distributions, where most of items are placed in the positive area (F1 that has only one item in the negative area of item index scores.

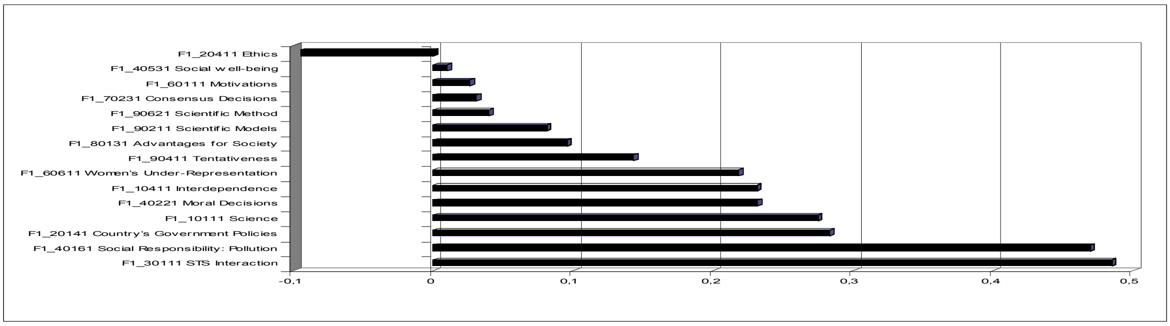

Figure 1. Average item indices for the 15 questions of the Form 1.

The items with the highest positive indices (more than one standard deviation above zero) identify the teachers’ strengths and weaknesses. The list of F1 and F2 items, which represent a teachers’ strength, is the following: F1_30111 STS Interaction, F1_40161 Social Responsibility contamination, F1_20141 Government politics a country, F1_10111 Science F2_10421 Interdependence Quality of life, F2_50111 Union two cultures, and F2_60521 Gender equity.

Some items reach negative scores in both forms (F1 and F2), though their mean indices do not attain low enough scores to be considered symmetrical to the positive ones. Nonetheless, the items with negative indices, which represent a teachers’ weakness, are the following: F1_20411 Ethics, F2_40421 Application to daily life, F2_90111 Observations.

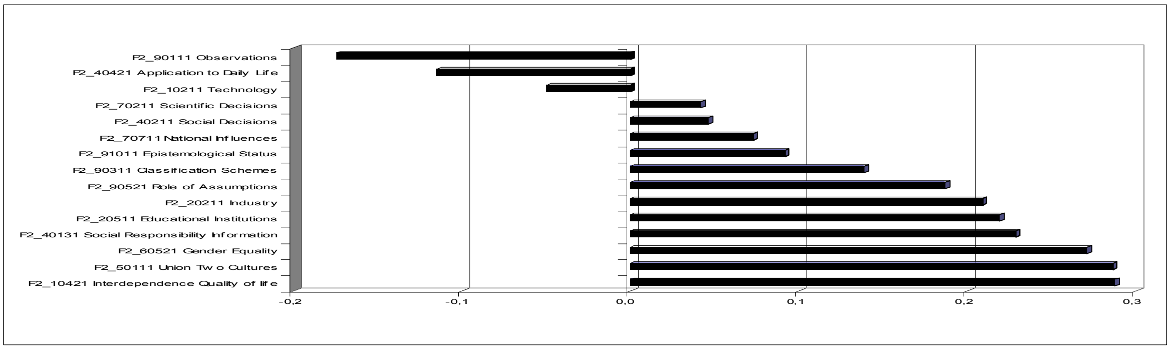

Figure 2. Average item indices for the 15 questions of the Form 2.

Similarly, the categorical and the sentence variables with highest positive and lowest negative indices could be used to identify the specific strengths and weaknesses. Each of the hundred sentences represents a specific conception on NoS, and the whole set conform the teacher’s thinking; approximately, two third of them do not attain a satisfactory level to be deemed quality conceptions for a fair science teacher. The number of these variables that are high and low is still greater than previous ones to be displayed here in the affordable space of this paper. The following example displays the classification of the sentences in an item as weakness, strengths, or medium, according to their mean index scores.

Table 2. Text of an item (10421) that displays the classification of its sentences as weaknesses (italic), strengths (bold), and medium, according to their mean index scores.

10421 In order to improve the quality of living in our country, it would be better to spend money on technological research RATHER THAN scientific research.

A. Invest in technological research because it will improve production, economic growth, and unemployment. These are far more important than anything that scientific research has to offer.

Invest in both:

B. because there is really no difference between science and technology.

C. because scientific knowledge is needed to make technological advances.

D. because they interact and complement each other equally. Technology gives as much to science as science gives to technology.

E. because each in its own way brings advantages to society. For example, science brings medical and environmental advances, while technology brings improved conveniences and efficiency.

F. Invest in scientific research – that is, medical or environmental research – because these are more important than making better appliances, computers, or other products of technological research.

G. Invest in scientific research because it improves the quality of life (for example, medical cures, answers to pollution, and increased knowledge). Technological research, on the other hand, has worsened the quality of life (for example, atomic bombs, pollution, automation, etc.).

H. Invest in neither. The quality of living will not improve with advances in science and technology, but will improve with investments in other sectors of society (for example, social welfare, education, job creation programs, the fine arts, foreign aid, etc.).

The previous table evidences some common features for all items: on each issue (item), the teachers hold at the same time strengths and weaknesses. Some sentences exhibit appropriate conceptions (A, D, G, H), while the remaining sentences feature uninformed conceptions, either a clear weakness (C) or a conceptions that not attain a sufficient high level to meet the teachers needs for a quality teaching of NoS (B, E, F).

Differences between pre-service and in-service teachers

The methodology allows the application of inferential statistics in hypothesis testing, in particular, the simplest form of testing refers to group comparison, which is applied here to compare NoS conceptions of pre-service and in-service teachers. To find out the variables that might display significant differences between groups, a two-way between-groups analysis of variance was conducted to explore the impact of teaching practice on teachers' NoS understanding, as measured by the three hundred variables of questions, categories and sentences (dependent variables).

Overall, few variables (19 for the form 1, and 24 for the form 2 of the total 300 variables involved in the two forms) displayed a statistically significant main effect ($p < .01$; $d > .30$) between in-service and pre-service teachers. However, the differences do not display the same sign, as some differences are positive (in-service teachers score higher than pre-service teachers), and other are negatives (in-service teachers score lower than pre-service teachers). Thus, not only the relevant differences are comparatively scarce, but also they do not display the same trend for all the significant variables favouring one group over the other.

Summing up, these results do not support the hypothesis that the practice of science teaching improves teachers NoS conceptions. This is evidence that improving NoS understanding requires explicit teaching of NoS contents, and implicit practices such as teaching science are not enough to improve teachers' conceptions.

CONCLUSIONS AND IMPLICATIONS

The new instrument and methodology improves the validity and reliability of the previous instruments and avoids the usual objections, such as forced answer (election of just one sentence). Moreover, they contribute to identify qualitative features, such as strengthens and weaknesses of NoS understanding, and to normalize the scores and analyses, which allows standardized application of the hypothesis testing statistics, such as comparisons among groups. On the other hand, the methodology allows quick and easy assessments for big representative samples, which overcomes the limitations to case studies or small samples, to identify the teachers' strongest beliefs (those that highly fit the experts' current knowledge), and the teachers' weakest beliefs (those that oppose the experts' knowledge).

The assessment instrument and method fit the requirements suggested by Allchin (2011) for appropriately assessing functional NoS understanding: authentic context, well-informed analysis, adaptability to diagnostic, formative or summative evaluation, adaptability to single, mass, local or large-scale comparative use and the respect for relevant stakeholders; further, the research project PIEARCTS is an example of large-scale applications across seven countries and involving over 16,000 valid answers (Bennássar-Roig, Vázquez-Alonso, Manassero-Mas, García-Carmona, 2010; Manassero et al., 2010).

The results provide a picture of teachers' NoS conceptions more complex than usual (Lederman, 2007): the teachers' poor conceptions coexist with the appropriate ones across all the NoS topics. Many teachers' NoS conceptions (about two third of explored conceptions) do not achieve the high level required to quality teaching of NoS. The appropriate beliefs could be educationally worth, because they can be used as pedagogical hooks in teacher training and the planning of teaching NoS curriculum.

It is usually agreed that years of teaching improves the teachers' pedagogical content knowledge, so that in-service teachers would have displayed higher scores than pre-service teachers (Abd-El-Khalick & Lederman, 2000; Lederman, 2007). In spite of this somewhat optimistic trait, the comparisons between pre-service and in-service teachers display scarce relevant differences: the differences in favour of pre-service teachers balance those in favour of in-service teachers, and both groups seem more similar than different. As Spanish teachers have not been taught on NoS (control variable), this study evidences that science teaching practice by itself does not contribute to refine the teachers' NoS conceptions. Thus, it would not be expected that teaching experience could (implicitly) train teachers on NoS. This claim agrees with the current compelling evidence in favour of explicit teaching of NoS.

All in all, the numerous inappropriate, or simply insufficiently appropriate conceptions found in the science teachers' thinking, together with the lack of effectiveness of teaching experience to improve this situation, put forward the necessity of designing and implementing training programs that involve teachers in an explicit and reflexive analysis of NoS topics for both pre- and in-service teacher education (Hanuscin, Akerson & Phillipson-Mower, 2006). The aim ought not to be teacherz become philosophers of science, or better knowledgeable on NoS, but more competent teachers to teach effectively NoS issues within science classroom.

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DEVELOPING CHILDREN'S VIEWS OF THE NATURE OF SCIENCE THROUGH ROLE PLAY

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Abstract: In this study, we aimed to investigate the effect of using role play (portraying a scientist‟s life story) on the children‟s views of the nature of science (NOS). The study was carried out at the Children‟s University of Trakya in Turkey in 2010. The research sample consisted of 18 children, aged 10 to 11. Children met for ten days for approximately three hours per day. They completed the pre- and post-tests including 16 open-ended questions in order to reveal changes in their views of the NOS before and after the role play activities. The findings revealed that the children had more informed views of the target NOS aspects in comparison to their views prior to the role play activities. A large majority of the children (around 80-85 percent) started out with naive conceptions of the target NOS aspects. Following the role play activities portraying scientists‟ lives, there was a 40-45 percent positive change in children‟s views of the tentative, empirical and creative/imaginative aspect of the NOS. The most substantial change occurred in their views concerning scientific method, with a shift of 72 percent. These results indicate that role play oriented activities portraying scientist‟s life stories could be used as one of the exciting and constructive ways of developing children‟s understanding of the NOS.

Keywords: Nature of science, role play, drama, primary science.

INTODUCTION

In the last two decades, the nature of science, as an essential component of scientific literacy, has become a slogan in science education all over the world. Many reform documents in science education (AAAS, 1993; NRC, 1996) emphasized the crucial role of enhancing students‟ informed views of aspects of the NOS. AAAS (1993) and NRC (1996) underlined that scientific fact/knowledge oriented science teaching focusing narrowly on the laws, concepts, and theories of science does not lead to an understanding of how science itself works. In order to overcome this deficiency, the strong focus for pupils in the early grades, should be on gaining experience with natural and social phenomena, and on enjoying science. Compared to traditional methods of science teaching, use of role play/drama to portray the lives of scientists may provide students with "a more authentic sense of science", especially regarding how science works (Boujaoude et al., 2005, p.259). Odegaard (2003), in her extensive review of the literature on drama activities in science education, emphasized that the use of drama in a well-considered manner with the guidance of reflective science teachers may offer creative and non-authoritarian learning environments for students. Through stories of science and the experience of enacting scientists‟ lives, students may gain better insight into the nature of scientific practice. According to Yoon (2006), two characteristics of science drama are worth of emphasis; 'story' and 'liveliness' of its performance. While events and characters in the „story‟ enable individual emotional participation and empathetic learning, the „liveliness‟ of science drama allows students to express and adapt their ideas in a learning environment which is quite non-authoritative.

Despite the successful performance of 'The Blegdamsvej Faust' drama in 1932 by Bohr's students, there is still a dearth of studies on role play/drama in science education. However, the few studies reported in the literature found that role play/drama has a positive effect on children‟s science learning. Bailey and Watson (1998) investigated the advantages of utilizing drama/role play in developing understanding of basic ecological concepts with students aged 7 to 11. They reported that a structured role play activity, the Eco game, as an active learning strategy appeared to have an important part to play in the generation of concepts relating to ecology. Boujaoude et al. (2005) explored the effect on conceptions of the NOS of using drama as a supporting learning strategy with older students from grade 10 and 11. At the end of the study, it was found that the students who participated in the drama activities possessed more informed the NOS views than the control group.

RATIONALE

In this study, we aim to investigate the effect of using role play activity portraying a scientist‟s life story on upper primary level children‟s views of the NOS. We focus on the tentative, empirical, denial of a prescribed scientific method and on the creative/imaginative NOS. By critically investigating scientists‟ lives and work methods and by role playing, students might become aware that scientists fail as much as they accomplish (Boujaoude et al., 2005, p.259), that they do not follow a universally accepted a scientific method, that science does not provide absolute proof, and finally students may substitute their naive NOS views with informed ones.

METHODS

The study was carried out at the Children‟s University of Trakya in the Northwest part of Turkey and was organized during the summer of 2010. The participants consisted of 18 children, aged 10 to 11. The study lasted two weeks (ten week days) and approximately three hours per day including breaks. The pre- and post-tests including 16 open-ended questions were used.

In this study, the life story of two scientists (Isaac Newton and Marie Curie) was selected for the role play activities to be performed by the children. The authors initially prepared a power point presentation about the lives of those scientists. Both researchers simultaneously supervised the participants during the role play activities. On the first day, after a brief introduction, the pre- test was given to the children. Then, in order to attract the children‟s attention to the lives of the scientists, the researchers directed various questions concerning the scientists. During this activity, students were all given the opportunity to express their ideas freely about the scientists and scientific process. This was followed with the presentation of the lives of two scientists.

On the second day, the children were divided into three groups of 6. While one group of children performed the role play, the others participated as the audience but the groups all had a chance to role play at least once. Performers initially were selected as volunteer among the children. Then, the researchers introduced a detailed step by step description of the life of Newton. At intervals during the presentation, the researchers portrayed the roles which children would be invited to play, and encouraged the children to focus on, talk and improvise about critical incidences in the scientist‟s life. Later, the authors, together with children‟s help, prepared the classroom so that the children could characterize some crucial instances in Newton‟s life. On the third day, the children performed the role play. The children were reminded by the authors what role they would play and given a brief outline of the situation to be portrayed. At each stage, children were encouraged to improvise within the situation to be portrayed.

On the fourth day, the children were experienced in role play, and thus performed their roles more successfully in a relaxed and pleasant atmosphere. Some students were really very eager to repeat the role play. Hence authors required the children to take turn in different roles as they performed with their classmates. During the role play activity, we explicitly asked a number of critical/taught provoking questions in order to touch aspects of NOS. "What do you think of how Newton showed the existence of gravity?" "Where is the gravity in this class?" In this way, children had an opportunity to think about the NOS. Fifth day started out with a small ice-cream party, aiming to encourage children to chat more enthusiastically and answer questions about the NOS e.g. "Do you think that Newton and previous scientists think same thing? Why?" The following week, a similar strategy was adopted illustrating the life of Marie Curie.

RESULTS

Student responses were categorized as naive and informed. Naive category represented inadequate responses with regard to the target NOS aspect. For example, some students stated that scientific knowledge was subject to change over time but attributed that change solely to the development of new technologies or the accumulation of new data. Informed category included responses referring reinterpretation of existing data from a different perspective. Student responses were initially categorised independently by two of the researchers. The researchers sorted out differences by reviewing the responses. Here, we report the children‟s responses to four questions in the pre and post-test. The question "Do you think that all scientific knowledge in your science books can *change* over time? Please, explain your reason" assessed students‟ understanding of the tentative NOS. Although only 3 children (17%) in the pre-test provided informed views about the tentativeness of science, this increased to 11 (61%) after role play activity. While one child in the pre-test determined change to be solely due to technological developments, in the post-test she stated that "different scientists may think differently and produce new things like atom models. Newton‟s ideas were different from the previous scientist." The question targeted the empirical nature of science asked children "For you, how science is different from the other subjects you are studying?" While 39 percent of the children gave relatively informed statements, this increased to 78 percent in the post-test. The following is a child‟s statements in the pre and post-test respectively: "Science explains to us everything in the world. Through the experiments, science provides absolute knowledge." "Science saves us from wrong knowledge. For science, investigating nature and space, and making experiments are very important."

The question about multiple methods of investigation revealed the most substantial shift in the views of children. Although none of the children initially held informed views of scientific method, following engagement with the role play activities informed views rose to 72 percent. For example, a child initially stated that "scientific method is very important. To be successful and practical, a scientist should simply follow scientific method and pursue the way of doing science as the previous scientist". However, after the role play, the same child stated that "I think deep thinking and questioning about things, like Newton, to be a better way of doing science. We do not need to memorize scientific method." When asked about the role of human creativity and imagination in science, informed views increased from 22 percent to 67 percent after role play. One child expressed that "Without imagination, scientist cannot put forth big things. Deep thinking and imagination help scientist to find out new things."

CONCLUSIONS AND IMPLICATIONS

Role playing scientists‟ life stories through the guidance of the reflective authors and explicit instruction appeared to have helped children‟s understanding of how science/scientist works, and finally develop a sense of the target NOS aspects. Although a great majority of children (around 80-85%) started out with naive conceptions of the NOS, following the role play activities portraying scientists‟ lives, they tended to develop more informed views of the target NOS aspects. The positive changes were observed for all of the NOS aspects with the most substantial change occurring with the questioning of universally accepted scientific method showing a shift from zero to 72 percent. The shift for the tentative, empirical and creative and imaginative NOS stayed about 40-45 percent. These results support using role play/drama activities to bring about positive changes in students‟ NOS views as previously stated by Boujaoude et al. (2005). It should be noted that in spite of the fact that role play activities improved the children‟s NOS views, just a two week intervention at the children‟s university may not be enough for assimilation and retention the meanings of the NOS aspects.

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PART 6: DISCOURSE AND ARGUMENTATION IN SCIENCE EDUCATION

Co-editors: *Manuela Welzel-Breuer and Conxita Marquez*

Understanding, supporting and promoting use of evidence and argumentation discourse in science education. Scientific practices related to knowledge evaluation and communication. Supporting the development of critical thinking. Discourse analysis. Talking and writing science in the classroom. Meaning making in science classrooms.

This part corresponds to strand 6. It contains 18 papers.

TABLE OF CONTENTS OF PART 6

DISCOURSE AND ARGUMENTATION IN SCIENCE EDUCATION

BUILDING CONTEXT AND CONTINUITY IN CLASSROOM DISCOURSE; A CASE STUDY AT THE HIGH SCHOOL LEVEL

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Abstract: In this paper, we will present a case study where we focus on the importance of temporal links in teachers' discourse in particular how these links participate in the drawing of classroom content from the beginning of the school year. From a sociocultural perspective and by taking the teaching learning process as a dynamic process, we build our work on three theoretical concepts: (1) the definition of *context and continuity* developed by the works of Mercer (1987, 2008), (2) the definition of macroscopic, *mesoscopic*, and *microscopic* scale taken from the works of physics education for studying the progression of knowledge in time (Tiberghien & al., 2007), (3) and finally the concepts of *themes* and *episodes* in order to organize the taught knowledge respectively at the mesoscopic scale and microscopic one. We will focus in this case study on two episodes situated in a same theme ("the representation of the solar system as an almost empty (lacunar) system"), and extracted from a video-recorded sequence at the beginning of the school year. The teacher in question is an experienced teacher. These two episodes describe how the teacher draws the *knowledge context* and ensure continuity of the class with regard to knowledge on a short scale and on a longer one. It is a study in progress that aims: (1) to understand how different teachers from different disciplines and different profiles manage from the beginning of the school year the construction and managing of knowledge in the classroom discourse, (2) to provide teachers with tools related to the managing of knowledge through time.

Keywords: dynamic approach of classroom interaction, context, continuity, time scale, discourse analysis

Our work is in line with the socio-cultural perspective. This study take into account the studies that highlight the temporal and dynamic dimensions of the progression of taught knowledge in the classroom discourse at a long scale teaching sequence. In this study, we treat classroom interaction as a dynamic process where time is considered as a major parameter in teaching and learning processes. We believe that each action in classroom has its own meaning with regards to the whole context and history shared between the participants (Badreddine, 2009). This dynamic approach is expressed and defined in works such Roth (2010, p. 114), for example, where he assumes that *" the relationship between thought and word is not held constant, which means that a word at the beginning of a lesson or at the beginning of an interview no longer expresses the same thought as it does at the middle of these events or at the end"*. This point of view is shared by works like Mercer (2000, 2008), Lemke (2001), Scott (1998), Mortimer & Scott (2003), Kelly (2007), Roth (2010), Badreddine & Buty (2011).

We consider that the discourse between teacher and students on the one hand and the way that teacher manages this discourse on the other hand, are essential elements for the construction of meaning during a teaching sequence. For Mercer (2000, p. 46), *"using language, we can* *transform the raw material of our shared life experiences into stories which have continuity and coherence"*. In other words, people that share the same space for a relatively long time are able to understand each other by referring to a past shared instant and to construct the future by referring to these shared moments. They construct a space where every element developed its own meaning with regard to the participants. In addition, Mercer (2008, p. 35) underlines that language is a *"prime tool for making collective sense of experience, and the extent to which students will perceive cohesion and coherence in their classroom work may be heavily dependent on how dialogue mediates that activity"*.

In this perspective, we will present a case study where we focus on the importance of temporal links in teachers' discourse, in particular, how these links participate in the drawing of classroom content from the beginning of the school year.

This work is a part of a European project. As part of this project, we have taken data in 4 different French schools in Physics, Math, and Biology lessons that evolve seven experienced teachers. This study aims to compare regularity and variability between the practices of teachers of a same discipline and of different ones. Our aim is to describe how teacher ensures the evolution of knowledge and of the class organization. We assume that these two dimensions are strongly linked and that students' access to knowledge depends on their management. We will focus in this paper on the first level: the evolution of knowledge in a class discourse.

THEORETICAL FRAMEWORK

We build our work essentially on three theoretical concepts:

(1) The definition of context and continuity developed by Eduards & Mercer (1987). Mercer defines continuity by referring to the context. From Mercer's point of view, context "refers to everything that the participants in a conversation know and understand, over and above that which is explicit in what they say, that contributes to how they make sense of what is said". Thus, *"continuity is the development of such contexts through time"* (Eduards & Mercer, 1987; p. 63). The term *continuity* refers to and puts a stress on the evolutionary construction of meanings through discourse interaction, establishing thus coherence between the meanings developed and presented in a past context and the present context (Badreddine & Buty, 2011, p. 778). It involves the idea that the meanings attributed to a taught content in a particular moment evolve during the sequence.

(2) The time scale defined in the work of physics education (Tiberghien & al., 2007) for studying the progression of knowledge in time, its coherence and continuity. These authors define three scales in order to describe and to organize class phenomena through time. In their study, Tiberghien & al. (2007, p.102) define three different time scales for an analysis of phenomena related to the teaching and learning process: *"the macroscopic scale that corresponds to the academic time (weeks and months), the mesoscopic scale that corresponds to the didactic time (minutes and hours), and finally the microscopic scale that represents a smaller granularity, around minutes and seconds. This microscopic scale is at the level of utterances and gestures of actors [...], the level of interactions"*.

(3) Finally, in order to organize the taught knowledge respectively at the mesoscopic scale and microscopic one, we borrow the concept of "theme" (idem) and "episodes" (Mortimer & al, 2007). A theme is defined as the *"central topic of a discussion during a given time interval in the classroom. These units have a structure, with boundaries and a thematic coherence. They include* *most of the time an introduction and a conclusion, the majority of utterances is connected to the same theme"* (Tiberghien & al., 2007, p. 97, our translation). A theme represents the central topic of the discussion during a given time interval in the classroom. *"The thematic units (Tberghien & al, 2007) [are used] in order to structure the taught knowledge at the meso-scale (time scale of a few dozen of minutes) by its content"*. As for the notion of episode, it represents *"a coherent set of actions and meanings produced by the participants in interaction"* (Mortimer & al., 2007, p. 61–62). The episodes provide access to the rhythm of the classroom life, the dynamics of the classroom interaction and progression of taught content, at the microscopic level.

Consequently, we are interested to underline how teacher assures the construction of a shared content during time from the beginning of the school year. We will be placed in this work at the level of the three scales defined above by presenting two examples on how a teacher, with his students, in a particular theme (mesocopic scale), relates the microscopic scale of taught knowledge with the macroscopic one by referring to a same-shared context.

CONTEXT AND DATA COLLECTION

The two cases that we will refer to in this paper are extracted from the fifth session (Figure 1) of a tenth grade class (high school level) where the teacher works with the student on elementary notions on the solar system. We are at the beginning of the year (Figure 1) where students and teacher are in a stage of getting to know each other. The teacher of this class is an experienced teacher and is engaged in a group of research and development of teaching sequences in physics and chemistry education. We have video-recorded, continuously during three months, the teacher in his moves and his interaction with his class along thirteen sessions. The recording of the entire sequence was a way to preserve the meaning of actions through time and their continuity over sessions.

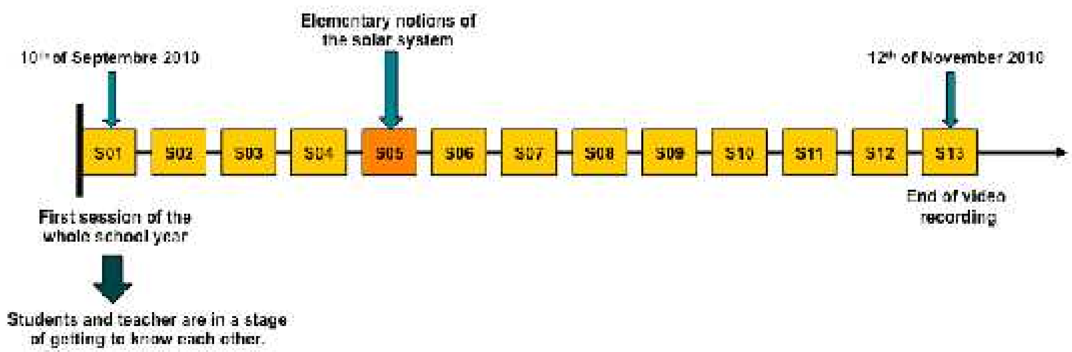

Figure 1. Sessions recorded from the beginning of the school year

METHOD OF ANALYSIS

Consequently to our theoretical positioning, our method of analysis consists in visualizing the sequence throughout its chronological progression in order to maintain how the context is co-developed in time between teacher and his students in interaction. We have broken down the session into themes at the mesoscopic scale and we have analyzed the discourse at the microscopic one by cutting each theme into episodes (Figure 2). The microscopic scale of an episode is the result of its adaptation with our assumptions: to see the construction of taught content during time, we have to be placed at the microscopic level (order of interactions and utterances) in order to study how knowledge is emerging in classroom discourse.

Putting in relation these two scales enables us to understand, from the one hand, how the knowledge emerges and how it is constructed and linked through the microscopic level (episodes), and from the other, to organize this content at the mesoscopic scale using themes.

For this study, we have selected episodes (Author's reference) that underline the temporal links that the teacher makes in his discourse. The division into episodes covers the entire sessions (Figure 2).

We have implemented our method of analysis on Transana®, a tool for transcriptions and analysis of qualitative data, in order to manage our set of data.

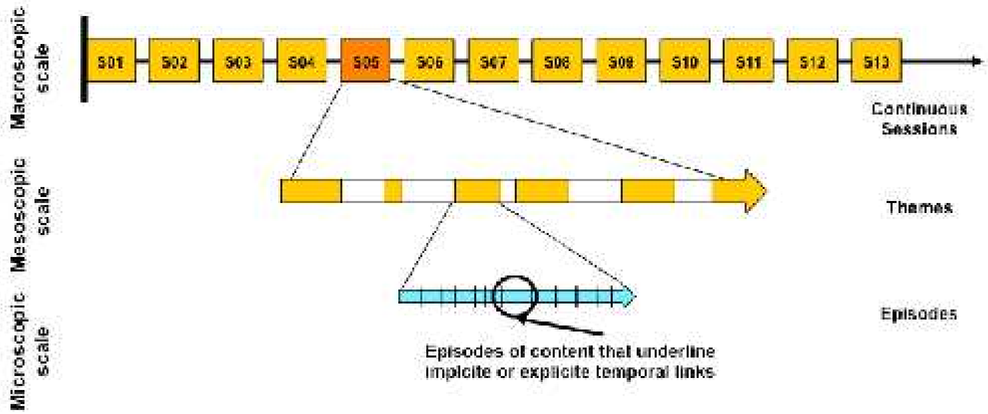

Figure 2. This figure represents the three scales that organized our study: the macroscopic scale at the first row, the mesoscopic scale at the second row and the microscopic scale at the final row.

RESULTS AND DISCUSSION

The two episodes that we will describe in this paragraph are localized in the theme "the representation of the solar system as an almost empty (lacunar) system" (Figure 3).

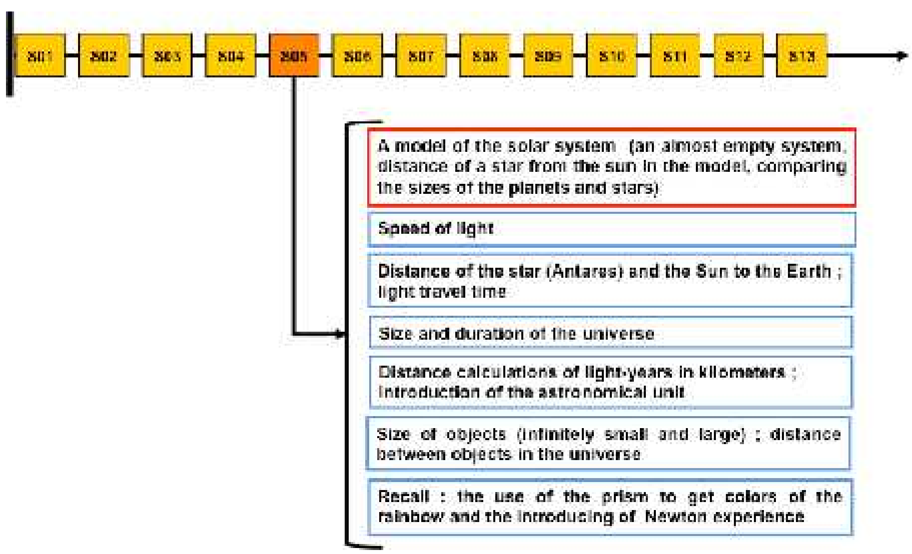

Figure 3. This figure represents the themes progression in the 5th session. The episodes, in which we are interested, are localized at the first theme of this session (red frame)

Long term continuity

The first episode (transcription below) is located at the conclusion of the activity "the model of the solar system, an illustration of an almost empty structure". In this episode the teacher indicates to the students the presence of another almost empty system other than the solar system and asks them if they know it. He then underlines and *announces*[1] that it "will be soon visited" (transcription 1, turn 3, underlined text).

1 Teacher: […] what does it mean that the solar system is lacunar (almost empty) […]/ there is fundamentally vacuum that's what we call lacunar (almost empty) ok (turns on the blackboard and writes) Solar System / The solar system we'll say is lacunar (almost empty) because it is fundamentally

2 Student: composed of

3 Teacher: […] is essentially lacunar (almost empty) because it's occupied by vacuum (end of writing), […] and there will be another system other types of system that will be very lacunar <u>as we will soon explore</u> / in your opinion what type of system

4 Student: the black hole

5 Teacher: […] oh no black hole is exactly the reverse / a black hole is the maximum density of matter we'll find nothing but matter it is exactly the opposite/ raise your hands so I'll give you

6 Student: atoms

7 Teacher: atoms

8 Student: molecules

9 Teacher: atoms and molecules/ an atom is mainly occupied by vacuum because there will be a small nucleus in the middle and the electrons around/ but there will be plenty of space at the atom scale between the nucleus and electrons ok so in fact even you / I think I've already said it

10 Student: we are constituted

11 Teacher: you are essentially made up in volume of vacuum

Transcription 1

In this episode, the teacher draws what we call a *long term continuity* where he prepares the students to the coming of a similar system later on in the sequence, "the atoms and the molecules" systems, as the students guess during the interaction with the teacher (turn 6 and 8). Students do not know when this topic will take place.

In this episode, the teacher puts an *anchor point* with the future by establishing a continuity of a taught content in physics with a chemistry content that will be introduced later on. The teacher gives information on the characteristic of the atom in advance. In addition, the teacher includes the students in a discussion built on future elements of the lesson ("in your opinion what type of

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[1] Categories of knowledge articulation defined in Badreddine & Buty (2011, p.784) : to announce, to call, to postpone, to resume, to advance, to remind.

system", turn 3), by having them name the other almost empty system (turn 6 and 8). We assume that this action has increased the bind of both students and content taught with the future.

Short term continuity

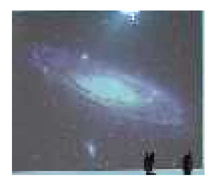
As for the second episode, it is located at the transition between the theme "a model of the solar system" and the theme " the speed of light" (figure 3). This episode takes place while the teacher project on the board a short film, which shows the differences between the sizes of planets situated in and outer the solar system. At the end of the film, while its last picture which represents the universe and the stars is displayed on the board, the teacher asks the students to "watch the diversity of colors" of the stars in the universe (transcription 2, bold text, picture):

Teacher Well it was another way of presenting things/ **watch the stars it will** <u>make a transition with the following</u>**/ watch the diversity of colors ok in the universe** the diversity of colors of the stars ok […]

Transcription 2

In this episode, the teacher makes an implicit reference to the theme of "the light spectrum and the phenomena of light scattering" presented in the session 4. This reference is done by transposing the context of an episode in the previous session (transcription 3, bold text and picture) to this session (session 5): "watch the stars […] watch the diversity of colors" (transcription 2, picture and bold text).

Teacher I 'll project a little picture (...) this is a galaxy (...) / **there are plenty of stars** in it/that appear white, but also there are things that appear yellow-orange others appear blue...**so effectively there is a large variety of possible colors** »



Transcription 3

In fact, when the teacher says "watch the stars", emphasizing later "the diversity of colors in the universe" while he refers to the picture on the board (transcription 2), he *calls* a content and a space shared with the students one day before. The teacher projected conscientiously during the session 4 a "little picture of a galaxy" (transcription 3). The similarities of the discourse and of the two pictures in these episodes call one another.

Furthermore, the teacher takes his time to prepare the student to what will happen in the next session (Session 6 and 7) by *announcing* that "it will make the transition with the following" (transcription 2, underlined text).

In this episode, teacher has made what we call a *short-term continuity* with the macroscopic scale between one session before (session 4) and two sessions after (sessions 6 and 7).

CONCLUSIONS AND PERSPECTIVE

This study aims to understand how different teachers from different disciplines and different profiles manage from the beginning of the school year the construction and the progression of knowledge in the classroom discourse.

By these two episodes, extracted from a session at the beginning of the year, we have underlined two examples on how a teacher draws the context of the class with regard to knowledge on a long scale (episode 1) and a shorter one (episode 2). Teacher draws different continuities of his context through time. We can see in these two microscopic episodes (the first lasts in the classroom discourse 45 seconds and the second 25 seconds) indices for a construction of a shared space for a common content.

We assume that by studying the practices of experienced teachers, this work will enable us to underline some of their performs and to bring tools to science teachers related to the managing of knowledge through time, more particularly, tools that enable teachers to explicit to students links between the past, the present, and the future of the taught content. This study is an analysis that will be extended to the other teachers (recorded in the frame of the S-TEAM project) in order to create collections of regularity and variability between teachers' practices. We believe that explicit these links to teachers and pre-service teachers, in order to use them efficiently in there teaching sessions, may increase students learning process. Furthermore, we aim to study the types of knowledge when links are made in the classroom discourse and the position of these links with regard to the progression of the lesson.

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EPISTEMIC FEATURES OF SCIENCE TEACHERS' TALK: COMPARING THE DISCURSIVE PRACTICES OF TWO SCIENCE TEACHERS

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Abstract: Contemporary reform efforts within science education emphasise the importance of teaching the content and methods of science, as well as promoting an understanding of the nature of scientific knowledge and the practices of science. One way to promote the epistemic nature of scientific practices in science classrooms is through teaching science using collaborative discourse and argumentation. Argumentation can be seen as a form of epistemic discourse, which can be fundamental to the development of students' epistemological understanding. Yet, little analysis exists of the epistemic discourse initiated by teachers, either in ordinary or argumentation-based instruction in order to model epistemic discourse for the students and prompt them to engage in this form of classroom talk. Therefore, this study, examined the epistemic discourse initiated by two science teachers observed teaching the same groups of Year 9 and Year 10 students throughout a school year, both during ordinary and in argumentation-based instruction. Epistemic discourse was framed based on epistemic operations such as explaining, describing, exemplifying etc. The results suggest that during argument-based instruction the epistemic operations of justification, prompts for justification and prompts for evidence were the most frequent and were dependent on the teachers' views of the nature of argumentation and its use in science education.

Keywords: epistemic discourse, epistemic practices, argumentation, secondary science, case studies

INTRODUCTION

During the last two decades and in light of considerations about scientific literacy and 'science for all' (AAAS, 1989) there has been a major shift in the goals of science education. That is, reform efforts in several countries in Europe, and the United States, now acknowledge the need for students to develop an understanding of issues such as the importance of evidence in the practice of science, the cultural and social influences of scientists, and the strengths and limitations that scientific knowledge possesses, in addition to aims about conceptual understanding and practical work (NRC, 1996, 2011; Millar& Osborne, 1998; Osborne & Dillon, 2008). An in-depth understanding of science means students should not only be aware of 'what we know' but also of 'how we know what we know and why we choose to believe it over alternatives' (Duschl, 2008, p.163). Thus, science educators need to address the epistemic practices that characterise the scientific endeavour. Kelly (2008) defines epistemic practices as 'the specific ways members of a community propose, justify, evaluate, and legitimise knowledge claims within a disciplinary framework' (p.99). This study argues that one way to foreground the epistemic practices of science within science education is to view the teaching of science as argument.

Argumentation is an integral practice of science which explores the construction and critique of scientific knowledge fostering not only the critical scepticism that is the hallmark of the scientist but also enhancing student conceptual understanding (Kuhn, 1993, Osborne, 2010). During argumentation-based instruction, students use evidence to support their claims and evaluate other individuals' claims and, in this manner, are enculturated into the discursive practices of scientists (Erduran & Jiménez-Alexaindre, 2008). Consequently, argumentation constitutes a form of epistemic discourse (Sandoval & Morrison, 2003); a way of talking that can help students develop a more informed view of the nature of science and its epistemic practices. Epistemic discourse could include instances of asking for evidence to support and justify a claim; making students consider opposing views and critically evaluate which one is better and why; explicit mention of the nature of evidence that students need to be using in their explanations and of the role of this evidence for their arguments; and providing or creating counter-arguments. The function of epistemic discourse is to help students acquire scientific knowledge whilst at the same time, engage students to the discursive and reasoning process necessary for that knowledge to be acquired.

Sandoval and Morrison (2003) argue that simply participating in activities where students need to construct their own explanations and provide evidence to support these explanations does not necessarily provide the means for students to develop an informed epistemological understanding. In their research, the students on which they focused had the opportunity to engage in such activities but at the end of the study, they did not demonstrate any substantial improvement to their understanding of the nature and role of scientific theories and evidence. Sandoval and Morrison (2003) add that students, in addition to engaging in such activities, need to be provided with opportunities to discuss the reasons and criteria they use for choosing one explanation over another, as well as to discuss the role of evidence for their explanations. As a consequence, 'to develop students' epistemological ideas, the nature of the discourse surrounding students' inquiry may be more important than the inquiry itself' (p.383). Ohlsson (1996) suggests that through an examination of the discursive actions of teachers and students, several epistemic operations can be identified, which promote higher-order thinking and understanding since 'collections of facts do not in and of themselves constitute understanding' (Ohlsson, 1996, p.48). These operations are Describing, Defining, Predicting, Exemplifying, Explaining, Critiquing (Arguing) and Evaluating. However, a careful examination of Ohlsson's list of epistemic actions shows that it is not exhaustive, as he suggests, since there could be other discursive epistemic operations carried out in classrooms, and especially the science classroom, such as compare and contrast, classifying, calculating and appealing to analogies and metaphors (Collins & Ferguson, 1993; Jiménez-Aleixandre et al., 2008; Mason, 1996). Utilising the notion of epistemic operations to analyse classroom talk during argumentation instruction is a way to identify the discursive actions of the teachers and find ways to help them model and further develop the use of epistemic discourse with their students.

RATIONALE

Research to date would suggest that there has been little analysis of the epistemic discourse initiated by teachers, either in ordinary or argumentation-based instruction. While there have been many studies of argumentation in the context of science education, many of these have focussed on student-student discourse and not on the nature of the discourse initiated by the teacher. As a result, this study aims to fill this gap in the literature. Specifically, the question of interest for this study, part of a professional development project aiming to help teachers incorporate argumentation into their everyday practices, was whether the use of argumentation-based activities enhanced the use of epistemic discourse in the science classroom when compared to 'ordinary' science lessons of two secondary science teachers.

CONTEXT OF THE STUDY

This study was conducted as part of a funded two-year Professional Development project (PD project hereafter) which aimed to help science teachers and their departments in four different schools to incorporate argumentation into their everyday practices. Argumentation was framed for the teachers based on Toulmin's (1958) framework of an argument, which consists of a claim; warrants or evidence; backings, rebuttals and qualifiers. Within each intervention school, two teachers acted as lead teachers for their departments. The lead teachers attended five workshop days during which they were introduced to the practice of argumentation, helped develop their knowledge of implementing argumentation in their science classrooms and at different age groups, and worked towards a dialogic perspective of science instruction. Subsequently, these eight teachers acted as lead teachers for their departments organising departmental reflective meetings and providing support to the science teachers of their own departments, which attempted to use argumentation activities in their science lessons.

METHODS AND ANALYSIS

This study utilised a qualitative case study design to create a detailed account of two teachers using argumentation and their students. The nature of the case studies developed were 'exploratory' emphasising the investigation of an event with the intent to create further hypotheses for future investigation (Yin, 2009). Two science teachers, from two secondary schools in London, one with a Year 9 class (13-14 years old) and one with a Year 10 class (14-15 years old), were followed throughout a school year. As a result, 13 lessons (6 argument-based) and 12 (4 argument-based) lessons respectively of the two teachers were observed in their classrooms. Lessons were video-recorded to capture the verbal interactions between teacher and students. The lessons observed focused on argumentation in different ways, varying in time, number of activities and topic investigated depending on the teacher's objectives and planning. Other data collected include teacher interviews to acquire a fuller picture of their conceptions about science, its nature and its practices and their beliefs about science teaching, learning and argumentation. In addition informal discussions with teachers about the lessons observed were hold and recorded in field notes.

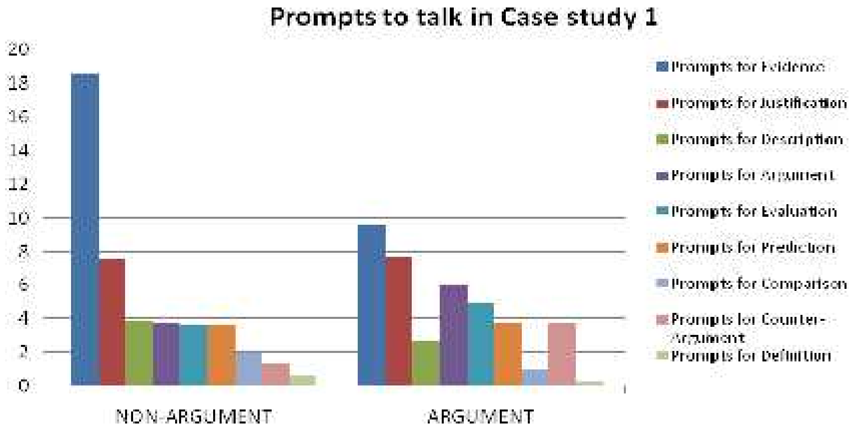
Participant sampling was based on convenience sampling aiming at teachers participating in the PD project, who would be prepared to share more of their time with the researcher and allow for lesson observations for an extensive period of time (one school year). Moreover, criteria such as the willingness to use argumentation even after the end of the PD project, confidence in teaching while observed, demonstration of enthusiasm and commitment to the PD project and an interest in the use of argumentation for teaching and learning science, were utilised to identify the two participating teachers. T1, a male science teacher in his forties with 20 years of science teaching experience at a mixed-comprehensive secondary school located in a quiet, residential area in the north-west of Greater London. T2, was a female teacher in her twenties with 3 years of teaching experience working at a mixed-comprehensive, secondary science specialist school in the north-east of Greater London.

Thematic analysis was used to code the transcripts of the lessons (Boyatzis, 1998) based on a theoretical framework of epistemic operations synthesised from the literature (Jimenez-Aleixandre et al., 2008; Ohlsson, 1996; Pontecorvo & Girardet, 1993). The software for qualitative analysis Nvivo 8 facilitated the coding process of the data. Initially, a reiterative process of open coding was utilised aiming at identifying the main themes coming out of the teachers' responses. The next step of analysis involved the revision and refinement of the themes identified to create overarching categories from the initial themes and use these categories to look for patterns within the case. The epistemic operations identified were framed based on (a) epistemic operations *performed* by the teacher, which were the discursive actions used by the teacher when s/he was attempting to explain, define, describe etc. an event and (b) the epistemic operations the teacher *prompted* students to engage in.

RESULTS

The analysis of the lesson transcripts for the two teachers, indicates that both teachers engaged in the epistemic practice of constructing knowledge claims through epistemic operations such as 'Provides Evidence/Information', 'Description, 'Explanation', 'Argument', Definition' and 'Generalisation'. In the two teachers' argumentation lessons, epistemic operations became more cognitively demanding and challenging as they started prompting students to provide their own arguments or provide justifications from evidence for their opinions/ideas. 'Justification' was utilised by both teachers, although not to the same extent. The justificatory aspect of the practice of argumentation was the strongest epistemic feature of T1's classroom talk, which was also one of the fundamental ways in which he conceptualised the notion of argumentation. Indeed 'the need to justify a viewpoint' was found to be the thematic emphasis in most of his argumentation lessons and the main way in which he distinguished between argumentation and non-argumentation lessons. What is more, T1 utilised 'Justification' and 'Prompts of Justification' as part of his non-argumentation lessons in a way and frequency, which were not substantively different to that of argumentation lessons (Figure 1).

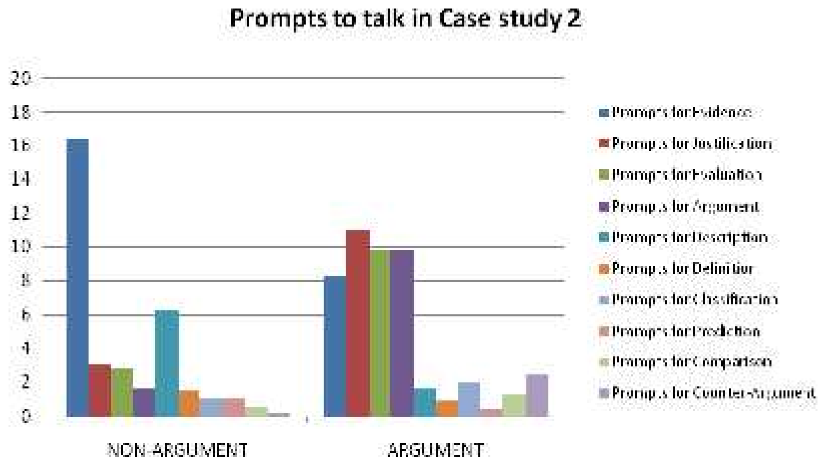
Fig1: The range of prompts in percentages T1 utilised as part of his argument and non-argument lessons



However, T1 did not consider other aspects of epistemic practices such as the need to evaluate knowledge claims and the need to portray to students the processes of evaluation and counter-argument that scientists often engage within their disciplines. As a result, attempts to evaluate claims critically and/or provide counter-arguments were less frequent, even in lessons where the argumentation activities focussed specifically on the evaluation of claims (Lesson 3).

In Case Study 2, T2 utilised 'Justification' and 'Prompts for Justification' consistently in her argumentation lessons, although this was not the case for her non-argumentation lessons, especially her use of 'Prompts for Justification', which was minimal (Figure 2). What is more, it was found that T2's use of justificatory talk was increasing as the year pasted, suggesting that she was still developing her use and understanding of argumentation as an instructional approach.

Fig2: The range of prompts in percentages that T2 utilised as part of her argument and non-argument lessons



Through the two case studies, it was established that the way in which the two teachers utilised epistemic operations and formulated their classroom talk was context-specific. In particular, the epistemic operations found in each teacher's talk depended on the type of lesson they were teaching (argumentation or non-argumentation) and within that, on the particular aspects of argumentation that they wished to address. For instance, Lesson 3 in Case Study 1, (an argumentation lesson) focused on selecting from a number of given statements in order to explain the fall of an object. As a consequence, during this lesson, the epistemic operations used the most were 'Justification' and 'Prompts for Justification' as students had to provide a reason for their selection of statements. Moreover, T2 seemed to use the epistemic operations of 'Prompts for Evaluation' and 'Prompts for Counter-Argument', in the argumentation lessons she taught as end-of-unit lessons (Lesson 1 and Lesson 5), which provided more opportunities for students to evaluate statements and make comparisons. The link identified between the context of the lessons and the epistemic operations that characterised these lessons is valuable in identifying and promoting those contexts that are potentially more likely to advance epistemic aspects of science. For instance, argumentation lessons as end-of-unit lessons could be used to apply and promote the role of the 'critiquer' (Ford, 2008a, 2008b), since evaluative processes seemed to be more evident in these lessons. Nevertheless, ways in which critique and evaluation can become part of everyday science teaching and learning also need to be explored. Students need to see evaluation and critique as an essential element of the process of knowledge generation if they are to grasp the epistemic nature of scientific knowledge and practices.

CONCLUSIONS AND IMPLICATIONS

The results of this study suggest that there is a developmental sequence of epistemic operations from lower-order operations such as description to higher-order operations of critique and evaluation. Thematic analysis of discursive interactions in the field of education has shown how images of science as a body of unequivocal and unquestioned knowledge is conveyed (Lemke, 1990). This study, through focusing on the nature of the teacher discourse and teacher-student interactions looked at whether the use of argumentation-based activities provides a means of transforming the dominance of IRE sequences (Initiation-Response-Evaluation) to one which demands the use of extended and higher-order reasoning by students. Although the data sample is small, the analysis provides an illustration of how the nature of classroom discourse can be transformed from providing declarative knowledge to students and relying on IRE sequences, to a developmental sequence of epistemic operations, starting from construction, moving on to justification and then to evaluation, which may advance epistemic discourse in the science classroom. According to recent recommendations (NRC, 2007) ‘students need support to learn appropriate norms and language for productive participation in the discourses of science’ (p.186) and argumentation can provide this support and assist students participate productively and persuasively in the discourses of science. Students will only begin to view the epistemic practice of science as such if teachers use the full range of discourse acts, or epistemic operations, which support such a practice. As a consequence, future research into ways of developing argumentation practices in science classrooms needs to introduce teachers to the practice of argumentation and at the same time, help them develop ways of structuring their talk in order to promote epistemic discourse.

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SCIENCE LEARNINGS AND DEBATES ON PAST BIODIVERSITY IN PRIMARY SCHOOL AND IN HISTORY OF SCIENCE

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Abstract : The first steps to learn paleontology in primary school and towards the creation of this area of study share similar problemes and obstacles. The choice of words and langage in a primary school discussion between 9-10 years old pupils on an historical controversy proved to be a fruitful moment. Disagreements centered round problem building and artificial objects used as scientific model were the source of confrontation and their interplay can be a double edged sword with problem building being either facilited or inhibited by the object in question. With 9-10 year olds the artificial object triggered a debate, raised questions and built reasoning. However, in the past it proved to be a bone of contention which frozen questioning in the sciences until 17th century in France. Identifying the issue gave rise to new paleontological questions and constructive discussion and criticism on both the heuristic and argumentative levels of the sciences as Voltaire and Guettard proved in the 18th century.

Keywords : In-class science debate, historical controversy, learnings and history of paleontology, epistemological rupture, problem-based learning

CONCEPTUAL FRAMEWORK AND QUESTIONS OF RESEARCH

This study would like to show the importance of controversies for learnings in sciences in order to prove some points of epistemological reference. To prepare the pupils, as future citizens, to develop questioning and argumentation, debat in class-room can be a favourable time. In reference to the construction of scientific knowledge, the historical controversies can be used like a mirror to understand and revisit problems (Popper, 1979) and obstacles (Bachelard, 1938) met by the scientific community. We have conceived a comparative study, didactic and historical, of problems in the field of palaeontology leads to a convergence about relations between problems and obstacles (Crépin-obert, 2010). This study concern the problem of the fossil origin linked to the artificialist obstacle. Two questions lead the research : what reasons are mobilized to explain fossils origin at two communities, classroom and history of sciences ? How the problem is constructed when they debated about a similar epistemic framework, the artificialism ?

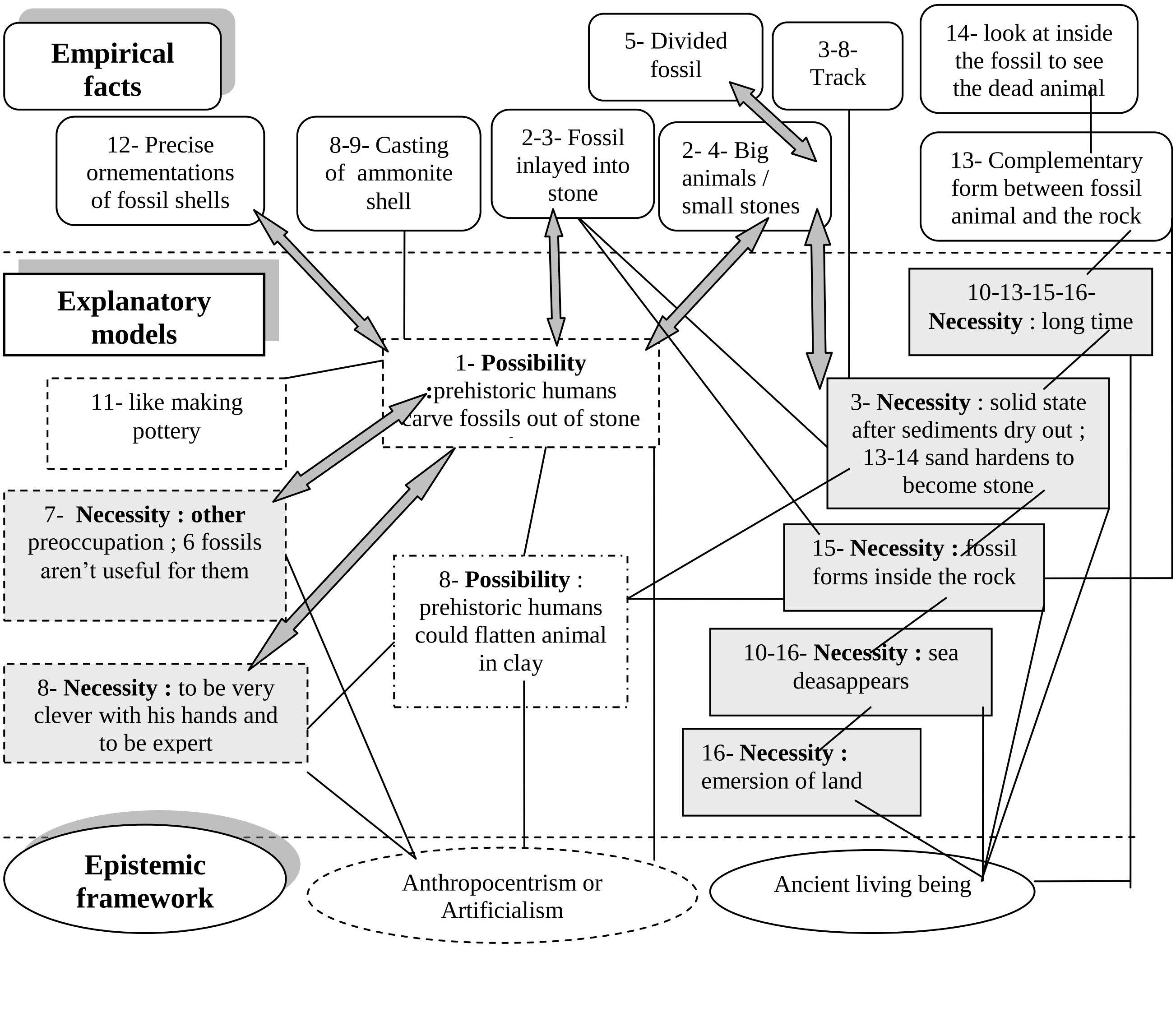
METHOD : A COMPARATIVE STUDY

The collective construction of paleontological knowledge is analysed within the theoretical and methodological framework of questioning coming from a science debates in-class and a historical and original controversy. The heuristic, argumentative and theoritical fonctions of these discussions are compared. Within the theoretical framework of problematization - building a problem- (Fabre and Orange, 1997), a study carried out in a primary school took an interest in transposing the methodology of space of the constraints (Orange, 2002) in the field of palaeontology in order to define the scientific learning objectives. The same tool is used to analyse the controversy in 18th century.

Debate in primary school

During a discussion in science, a co-construction spread between empirical facts in bond with a diversity of fossils and explanatory models. The reasons evoked by the pupils, guided by the teacher are mobilized according to several epistemic frameworks, such as artificialism anthropocentrism, or materialism (schema n°1). The argumentation puts in relation cognitive divergent ideas and scientific methodology. What leads the pupils to raise their questions becoming legitimated (Maulini, 2005), as "Have fossil schells been made by prehistoric humans ?". These various epistemological obstacles were located in history of sciences which bring a retreat necessary for their analysis.

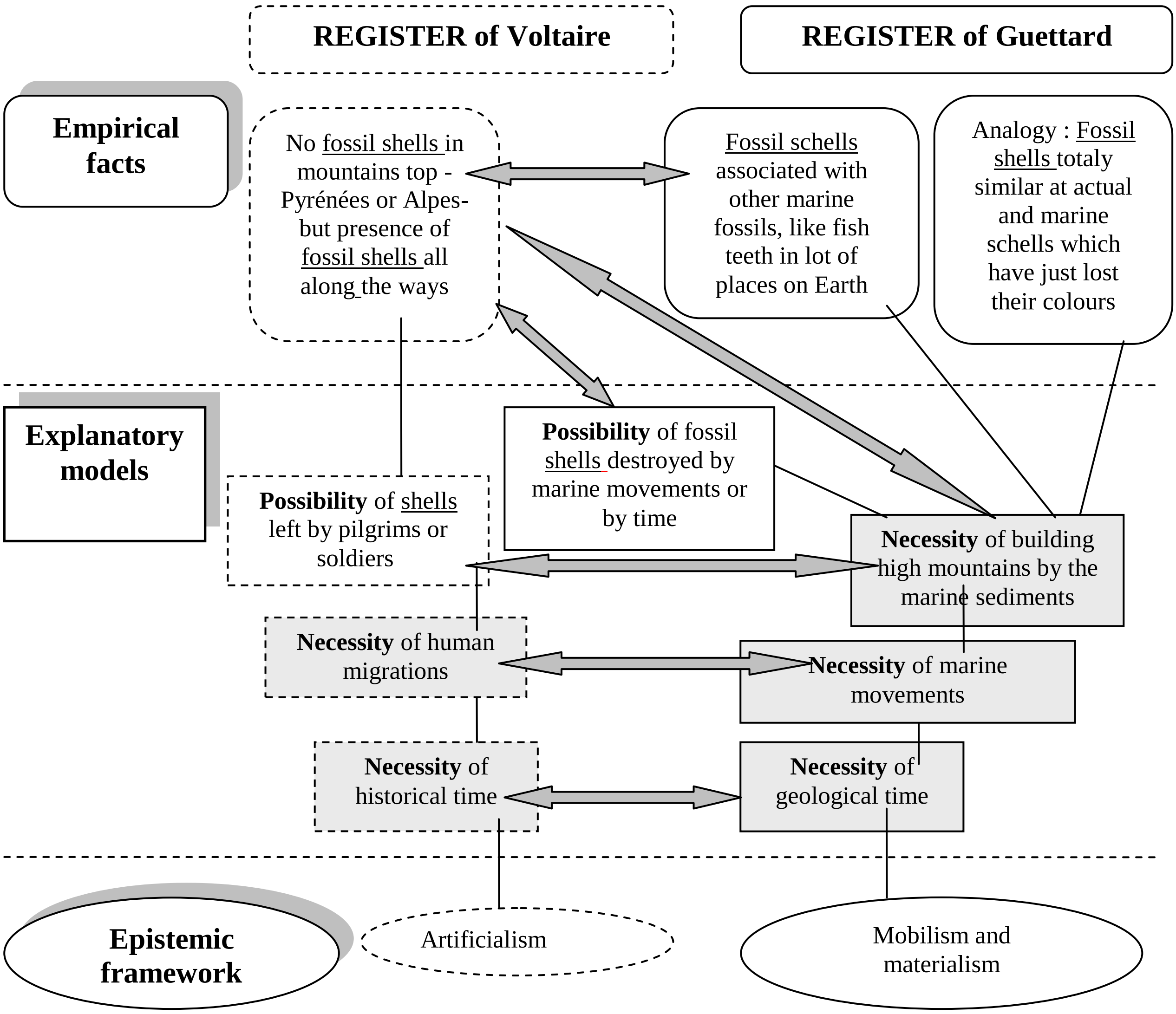
Schema N°1 **: Space of the constraints and the possibilities, an extract of debate in a primary class-room (9-10 years old)**



Historical controversy between two popular well-known people, a scientist and a scholar of 18th century, Guettard and Voltaire.

Voltaire defended the idea of artificialist origin for fossil shells, why not left by pelgrims or soldiers who crossed montains ? Guettard was at odds and defended analogy between fossil shells and actual marine shells. So, the scientific community thaught about necessary marine origin and so necessary marine movements a long time ago.

Schema N°2 : **Space of the constraints and the possibilities about fossil shells and Earth formation:** "When Guettard answers Voltaire fossil shells"



DISCUSSION ABOUT THE COMPARATIVE STUDY

We can end up in several levels of constructions of problems in didactic and in history of science ; furthermore we can notice different relations between problem and obstacle (Peterfalvi, 2006). More, we can separate process of paleontological knowledge, marked by the possibilities and the requirements mobilized by two communities under discussion. Firstly, even the results appear similar with common problem and obstacle, the process are different in the two discussions. The tension between two registers, empirical and explanatory, is especially interesting to compare. The pupils come in questioning and try to find several explanations based especially on possibilities and implicit necessities. In fascinating charges the initial problem thus, problematization requires three specific learnings : how to learn to distance empirical register from explicative register, how to learn to argue and how to learn to question the scientific objects and models. Where as, in the historical discussion, the two opponents built explicit necessities or impossibilities. Moreover, the points of view of protagonists mobilized differently two scientific registers. Over this hypothesis of pilgrims, laughed at by Buffon then by Guettard, Voltaire proposed, in fact, four others hypothesis on origin of fossil shells (Carozzi, 1983). He built his research on heuristic argumentation mainly to fight against the idea of Deluge. While Guettard only retained biological and geological facts and was afraid to propose some theorical ideas.

The pupils, the teachers and the great public keep a fascination for current subject like human fossils and their age or their relationships, fossil dinosaurs and their causes of disappearance or their relations with living birds, in general the origin and the extinction of species (Rudwick, 1985; Gould, 1989). The analyse of past controversies around fossil shells allows to understand these nowadays controversies about past or current biodiversity. Generally, it allows to define the nature of the scientific knowledge, that is to say : explanatory, debated, temporary and always may be refutable (Popper, 1979). The history of the living beings, accepted today, will allow a lot of new developments. Impossibility, possibility and necessity are epistemolgical references to construct scientific knowledge, better than mistake and truth. They could be an alternative method to define the scientific learning objectives which can favour scientific teaching : to distance empirical register from explicative register, to argue and to question the scientific objects and models.

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THE CASE OF DESIGNING AND VALIDATING A TOOL TO ASSESS 11-14 YEAR OLD STUDENTS WRITTEN ARGUMENTATION

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Abstract: The purpose of this paper is to present the process of designing and validating a tool to assess 11-14 year old students written argumentation in science. Given the emphasis in argumentation in science education in the recent years, methodologically the assessment of argumentation has become one of the dominant issues in the field. In this paper we present two written argumentation tools that were designed for 11-14 year old students, the validation process, and the main outcomes from testing the argumentation tools with 246 students in the UK. The analysis of the data from two versions of the questionnaire (Test A and Test B) show that both tests are reliable for evaluating written argumentation when the first item is removed (Cronbach's alpha .674 for Test A and .705 for Test B). Additionally the analysis of the data implies that choosing a convincing argument is more difficult for the students than any of the other three aspects of argumentation that were evaluated in these tests (choosing a convincing counterargument, writing an argument, writing a counter-argument). Finally, the results from the questionnaire suggest that argumentation might be content specific. Implications for research include the design of a new tool combining the questions from both tests, using aspects of the questionnaire to explore whether argumentation is context specific, and exploring whether deciding on a convincing argument is a higher sub-skill compared to writing an argument.

Keywords: argumentation, evaluation, written assessment, reliability, science

INTRODUCTION

Argumentation has been a prominent field in the science education community for the past years (Jiménez-Aleixandre & Erduran, 2008) and recent reports in the field identify the need for a science education that places an emphasis on understanding argumentation and explanation as part of the practice of science (Duschl, Schweingruber, & Shouse, 2007). Students' arguments have been analyzed using a variety of methods and data sets – researchers have analyzed interviews in which people engaged in argumentation, videos of people constructing arguments, students' artifacts created during the instruction, and written essays (e.g. Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Erduran, Simon & Osborne 2004; Sampson & Clark, 2008). However, according to published research no single valid instrument exists to evaluate young students written argumentation skills, a tool that can potentially be used as a measure of whether students improve or not their argumentation during the instruction. Hence, the main purpose of this study was to design and evaluate a questionnaire to assess students' arguments through a combination of open-ended and Likert scale questions. Therefore, the research questions explored in this paper are:

(a) Is the current assessment tool an appropriate tool for measuring students' argumentation skills*?*
(b) What can we say about students' written argumentation skills based on this test?

RATIONALE/IMPORTANCE

As stated above, argumentation has been the emphasis of many studies in recent years, however we do not have valid tools to help us evaluate students' written argumentation and enable us as researchers to follow the progress of students, and measure the impact of research programs. Consequently, teachers do not have a consistent way to measure their students' performance in argumentation. Hence this study is important since it seeks to explore this relatively new area, and additionally help us understand whether such a tool is appropriate for the evaluation of argumentation. The theoretical framework underlying the design of theassessment test was that of Toulmin's (1958) view of the elements of an argument. According to Toulmin's framework the essential elements of an argument are claims, data, warrants and backings. Counter-arguments are also important, especially in a dialogue, since one of the reasons that students should develop their argumentation skills is to enable them to evaluate claims and data and decide, in their everyday life, whether an argument is valid or not (Millar & Osborne, 1998).

METHODS

In order to test whether the current assessment tool is an appropriate tool for measuring students' argumentation skills a mixed-methods approach was used. The initial pilot testing of the questionnaire was based on open-coding, whilst the validation of the questionnaire was based on a statistical analysis of the responses provided. Several versions of the assessment tool were designed and pilot tested before finalizing the two versions presented in this proposal (Test A and Test B). Each test includes four items, each one designed to test an aspect argumentation as shown in Table 1 below. The choice of these four parts is based on the structure of argumentation, and the fact that argumentation is seen as a means of understanding knowledge and advancing new knowledge (e.g. Driver, Newton & Osborne, 2000). Hence the decision to ask students to choose the most convincing arguments and counter-arguments and then construct their own arguments and counter-arguments lies in the fact that both are part of the argumentation framework that informs the design of this study (Toulmin, 1958). Table 1 below provides an overview of the parts of the two questionnaires, and the context for each of the questions.

Table 1: Overview of structure and content of the two questionnaires

	Choosing a convincing argument	**Choosing a convincing counter-argument**	**Constructing an argument**	**Constructing a counter argument**
Test A	Q1a: Is current used up in a simple electric circuit?	Q2a: Light travels from our eyes to objects?	Q3a: Using chemicals to kill mosquitoes?	Wind energy vs. nuclear factories
Test B	Q1b: Explaining a breath vs. heart rate graph.	Q2b: Weather conditions under which it is possible to snow.	Q3b: Choosing the hardest rock from a list and explaining.	Q4b: Should we use mobile phones at school?

Each one of the four items was evaluated based on argumentation levels. These levels indicate the quality of the argument based on a modified version of the Erduran et al., (2004) framework: Level 4: (most convincing argument) data, warrant, and rebuttal; Level 3: warrant and data; Level 2: warrant only OR data only; Level 1: appeal to authority; Level 0: contradicts the claim or no response.

The questionnaires were administered to a total of 246 students (11-14 years old) in public and private schools in London and suburbs, with 114 students completing Test A and 132 students completing Test B. The decision to design two shorter versions of the tool instead of a longer one was based on observations from the initial piloting of the tool (e.g. the longer version was time consuming). The responses were coded based on the modified version of the Erduran et al. (2004) framework, and then the data were analyzed in SPSS.

RESULTS

Cronbach's alpha, which is a measure of the internal consistency of the items, was calculated for each of the tests. Cronbach's alpha for Test A was .605, and for Test B was .616. The inter-item correlation for both tests (Test A and Test B) which explores if the four items in each test correlate is presented in Tables 2 and 3.

Table 2: Inter-Item Correlation Matrix for Test A

	Q1	Q2	Q3	Q4
Q1	1	0.095	0.187	0.129
Q2	0.095	1	0.459	0.317
Q3	0.187	0.459	1	0.474
Q4	0.129	0.317	0.474	1

Table 3: Inter-Item Correlation Matrix for Test B

	Q1	Q2	Q3	Q4
Q1	1	-0.002	0.14	0.126
Q2	-0.002	1	0.483	0.333
Q3	0.14	0.483	1	0.524
Q4	0.126	0.333	0.524	1

As evident by Cronbach's alpha for both tests, the internal consistency was relatively low in the two tests, with Test B having a slightly higher consistency than Test A. Additionally, the correlation of items in Tables 2 and 3 show than there is a low correlation between Q1 and the other items in both tests. Therefore the scores for Question 1 were removed from both tests and Cronbach's alpha was calculated again as .0674 for Test A and 0.705 for Test B. The internal consistency is relatively high for both tests when the first question is removed from the total scores.

CONCLUSIONS

The analysis of the data from two versions of the questionnaire (Test A and Test B) show that both tests are reliable for evaluating written argumentation when the first item (Question 1) is removed. Additionally, the analysis of the data suggests that argumentation is evaluated best with open ended-questions (Q3 and Q4) since by removing either items Q1 and Q2 from both tests Cronbach's alpha is relatively higher than when removing either items Q3 and Q4 (see Table 4 below).

Table 4: Cronbach's Alpha if Item deleted for both tests

	Cronbach's Alpha if Item Deleted for Test A	Cronbach's Alpha if Item Deleted for Test B
Q1	0.674	0.705
Q2	0.508	0.532
Q3	0.394	0.361
Q4	0.489	0.478

The above implies that choosing a convincing argument is more difficult for the students than any of the other three aspects of argumentation that were evaluated in these tests (choosing a convincing counterargument, writing an argument, writing a counter-argument). Finally, the results from the questionnaire imply that argumentation might be content specific since for the same structure of the two tests, Test A had a lower Cronbach's alpha, and that was higher when Question 1 (which was heavily relying on students' knowledge on electric circuits) was removed. The hypothesis that argumentation is context specific is also supported from findings in previous studies (e.g. Means & Voss, 1996).

IMPLICATIONS

Implications for research include the design of a new tool combining the questions from both tests to see if this provides a higher internal consistency measure, and also using aspects of the questionnaire to explore (a) whether argumentation is context specific, and (b) that deciding which is a convincing argument is a higher sub-skill. Since the findings from this study suggest that choosing a convincing argument from a list of given arguments is more difficult that constructing an argument, implications for practice include finding ways to support students when deciding upon convincing arguments, since this is a skill useful in their everyday life.

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TRACING OF STUDENTS' SCIENTIFIC ARGUMENTATION QUALITY

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Abstract: The study of argumentation is still a young field and more research needs to be carried out on students' argumentation quality. Therefore, the purpose of this study was to examine the quality of students' argumentation and to find out how their argumentation quality changed as their involvement in scientific argumentation increased. Case study design was guided the research. The participants of the study were 13 senior pre-service physics teachers, four of whom were females. Argumentation sequences were implemented in the methods course and lasted six weeks including two subjects, i.e. kinematics, and heat and temperature. Data were collected via students' worksheets and video recordings made during the argumentations. The current study concludes that students' argumentation quality does not increase as the number of argumentation and their involvement in argumentation increase. Second, if students have familiarity with the concepts that are argued on, they can reach the highest quality level of argumentation although they do not have any experience with argumentation process in their previous instructions. Third, changing of subjects in argumentation may get students' interest and thus affect their quality of argumentation. Fourth, concepts that argumentation is founded on can influence argumentation quality. Finally, there is no consistency in students' argumentation quality through argumentation sequences when content as well as context of argumentation change in each sequence. This study has implication of presenting the changes in students' argumentation quality in scientific argumentation sequences.

K*eywords*: Argumentation, argumentation quality, physics, case study, qualitative analysis.

BACKGROUND AND PURPOSE OF THE STUDY

The need to educate students and citizens about how we know and why we believe requires a focus on 1) how evidence is used in science for the construction of explanations, and 2) on the criteria used in science to evaluate the selection of evidence and the construction of explanations (Duschl & Osborne, 2002). "It is an argument that we are likely to find the most significant way in which higher order thinking and reasoning figure in the lives of most people" (Kuhn, 1992, p. 156).

The practice of argumentation means the sociocultural activity of constructing, presenting, interpreting, criticizing, and revising arguments (Duschl & Osborne, 2002; Johnson, 2000; Leita˜o, 2000; van Eemeren et al., 1996). When constructing an argument, individuals consider both sides of the issue, explain aspects of the problem that are anomalous to their existing conception, and must be confronted with the discrepancy between their point of view and the alternative (Nussbaum & Sinatra, 2003). Research on argumentation in science education has expanded and intensified considerably over the past two decades (Sampson & Clark, 2008). However, the study of argumentation is still a young field and more research needs to be carried out on students' argumentation quality. Therefore, the purpose of this study was to examine the quality of students' argumentation and to find out how their argumentation quality changed as their involvement in scientific argumentation increased.

RATIONALE

Reviewing of the literature revealed that only a few studies have traced students' involvement with argumentation. Kuhn, Shaw and Felton (1997) states that if both the numberof argumentation and intervention time are raised, the quality of participants' argumentation increases. When children engage in such a process, and support each other in high-quality argument, the interaction between the personal and the social dimensions promotes reflexivity, appropriation, and the development of knowledge, beliefs, and values (Erduran, Simon & Osborne, 2004). The context and content of argumentation affect participants' argumentation quality (Duschl & Osborne, 2002; Kelly, Druker & Chen, 1998). Crossa, Taasoobshirazib, Hendricksc and Hickeya (2008) present association between the systematic contribution of quality argumentative statements and the demonstrated increased understanding of the scientific concepts through increased scores. This current study would contribute to the literature toward a better understanding of how students' quality of argumentation changes as they are arguing about scientific claims.

METHODOLOGY

Case study design (Stake, 1995). was guided during this research in order to investigate the relationship between quality of argumentation and students' involvement in scientific argumentations.

Participants and Settings

The participants of the study were 13 senior pre-service physics teachers, four of whom were females. Participants of the study had completed all the necessary physics courses. The participants had been taught in traditional environments in their courses until the methods course and not had any experience with argumentation as a teaching strategy. It was the first time that the participants were being a part of argumentation context in the class.

Instructional Context

Argumentation sequences were implemented in the methods course and lasted six weeks including two subjects, i.e. kinematics, and heat and temperature. The duration of each sequence was approximately 50 minutes. Argumentations in the first three weeks were related to kinematics.

Since the preservice teachers had completed all of their physics courses and had previous knowledge of the physics subjects, the aim of the instruction was to provide opportunities for them to involve in argumentation process and to argue about scientific concepts instead of teaching physics.

Table 2 presents content, related physics concepts and context for each argumentation. The context and content of argumentation affect participants' argumentation quality (Duschl & Osborne, 2002; Kelly, Druker & Chen, 1998). For these reasons, different contents, contexts and concepts of argumentations were implemented. Argumentation worksheets were distributed to the students at the beginning of each sequence. The participants argued with each other in groups and then they shared their ideas as well as their supports with whole class. Meantime, they wrote their explanations in their worksheets.

Data Collection Methods

Data were collected via students' argumentation worksheets and video recordings made during the argumentations. Argumentation worksheets that measured several concepts such as velocity, speed, projectile motion, free fall, air friction, expansion, temperature, heat, buoyancy force, gases and pressure, included open-ended questions about topic. Mostly, these worksheets included question of interpretation in order to be connected with students' experiences easily and to increase their participation. The participants and the instructor were videotaped during the instruction. Students' voice records and videotapes were transcribed into writing documentations for coding as well as written arguments.

Data Analysis

Clark and Sampson (2008)'s model was used to code arguments and analyze the students' quality of argumentations. Their model was chosen because of its comprehensibility and was showed in Table 1. Coding was done by two researchers and repeated until agreement was reached. Quality level of argumentation was determined in terms of the number and quality of rebuttals in the argumentation. For example, Level 1 means that argumentation involving a simple claim versus counterclaim with no grounds or rebuttals and Level 5 means that argumentation involving multiple rebuttals and at least one rebuttal that challenges the grounds used to support a claim.

Table 1: *Coding of argumentations' quality*

Quality Level	Quality Characteristics of the Discourse
Level 5	Argumentation involving multiple rebuttals and at least one rebuttal that challenges the grounds used to support a claim
Level 4	Argumentation involving multiple rebuttals that challenge the thesis of a claim but does not include a rebuttal that challenges the grounds used to support a claim
Level 3	Argumentation involving claims or counterclaims with grounds but only a single rebuttal that challenges the thesis of a claim
Level 2	Argumentation involving claims or counterclaims with grounds but no rebuttals
Level 1	Argumentation involving a simple claim versus counterclaim with no grounds or rebuttals
Level 0	Non-oppositional

In our study we used this coding scheme that is developed by Clark and Sampson (2008). There is an example for coding argumentation quality of Level 3 showed as below:

Example for Level 3 coding:

Teacher:	People who are making Wing-Suit sport, must get down to the ground safely. How can they provide this safety?
Student A:	They can use parachute (**claim 1)**.
Student B:	or they can get down over the sea.
Student A:	But, water is behaving as concrete after a specific height (***rebuttal against thesis****)*.I think, they should open their parachute from sepicif heigh from the ground (**claim 2**). We shouldn't do anything that we did while speeding (**claim 3**), for rexample, we need to take wind behind of us in order to speed up, however, we need to go through the wind now (**support 1**).

Table 2: *Content, concepts and context of argumentations.*

	Argumentations					
	First	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**
Content	Motion of a car	Children throwing stones in a pole	Flying sportsmen wearing wingsuits	Decision about the most efficient thermometer	Mechanism of a hot-air balloons	Finding a correct theory for each phenomenon
Concepts	Velocity, speed	Projectile motion	Free fall, air friction	Expansion, temperature, heat	Buoyancy force, gases, pressure	Heat, energy, temperature
Context	Explanation for a phenomenon	Selection of a scientific claim	Prediction, observation, explanation	Controversial dialogues	Designing and comparison of a vehicle	Matching of a theory with a phenomenon

RESULTS AND DISCUSSION

Table 3 shows the students' quality of argumentations. According to the table, it is not possible to mention either a constant increase or decrease in the students' quality of argumentations from the first argumentation through the last one because of different content, concepts and context of argumentations. . This result in a contradiction with the results of Kuhn, Shaw and Felton (1997) who found that if both the number of argumentation and intervention time are raised, the quality of participants' argumentation increases. This contradiction may be resulted from different content, concept and context of argumentations. Another finding is that majority of the students were able to reach Level 5 and produced multiple rebuttals in their arguments although they had not required constructing argumentations in their previous teaching and learning experiences. The reason for this finding might be that the students had previous knowledge of physics concepts that they argued about. This conclusion is in line with the results of other researchs. For instance, Crossa, Taasoobshirazib, Hendricksc and Hickeya (2008) reported that students tended to feel more comfortable and be more competent in arguing about concepts when they were sufficiently knowledgeable about that subject.

Since the subject of the argumentation changed from kinematics to heat and temperature after the third argumentation, within analyses were done in the first three argumentations and in the last three argumentations separately. Table 3 also illustrates that the number of Level 5 was highest in the first and fourth argumentations. In other words, when the students started to argue about new subjects, they could create more quality rebuttals. The students might start to the new subject with enthusiasm and then they might loose their interests as they more argued about the same subject although the concepts in the argumentation were not the same. Most of the students' quality levels of argumentation were low during the second and fifth argumentations comparing to the previous ones. For example, the quality level of Student 5's argumentation decreased from 5 to 0 from the first argumentation to the second argumentation and increased to 4 during the third argumentation. In addition, Student 7's argumentation quality reduced from Level 5 to Level 2 from the fourth argumentation to the fifth argumentation and rose to Level 5 again during the sixth argumentation. This result may come from the concepts of argumentations. In the second argumentation, the students gave their answers by depending on the formulas. Hence, they did not need to discuss about the various situations. In the fifth argumentation, the students struggled with arguing about the concepts of buoyancy force and pressure which the students found hard. When the students were analyzed individually, it was realized that there was no consistency in the students' argumentation quality throughout the argumentation sequences. For instance, even though Students 1, 4, and 7 could achieve Level 5 three times through six argumentations, they could not demonstrate any opposition and stayed in Level 0 one time. Since the content and context of each argumentation was different, it is not possible to relate the quality of argumentation with either content or context of argumentation.

Table 3*: Quality of argumentations*.

	Argumentations					
Students	**First**	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**
Student 1	Level 5	Level 0	-	Level 5	Level 3	Level 5
Student 2	Level 0	Level 0	Level 0	Level 0	Level 4	No participation
Student 3	Level 3	No participation	-	Level 5	Level 4	Level 5
Student 4	Level 5	Level 0	Level 4	Level 5	Level 5	-
Student 5	Level 5	Level 0	Level 4	Level 3	-	Level 0
Student 6	Level 0	No participation	Level 3	Level 5	Level 1	Level 0
Student 7	Level 5	Level 0	Level 3	Level 5	Level 2	Level 5
Student 8	Level 2	Level 0	-	Level 5	Level 4	Level 4
Student 9	Level 5	Level 0	Level 4	Level 5	Level 0	-
Student 10	Level 3	Level 0	Level 5	Level 5	Level 2	-
Student 11	Level 4	No participation	Level 5	Level 0	Level 3	Level 0
Student 12	-	No participation	Level 0	No participation	Level 0	Level 0
Student 13	-	Level 0	Level 1	Level 0	Level 3	Level 0

CONCLUSION AND IMPLICATION

The current study concludes that students' argumentation quality does not increase as the number of argumentation and their involvement in argumentation increase Second, if students have familiarity with the concepts that are argued on, they can reach the highest quality level of argumentation although they do not have any experience with argumentation process in their previous instructions. Third, changing of subjects in argumentation may get students' interest and thus affect their quality of argumentation. Fourth, concepts that argumentation is founded on can influence argumentation quality. Finally, there is no consistency in students' argumentation quality through argumentation sequences when content as well as context of argumentation change in each sequence.

This study has implication of presenting the changes in students' argumentation quality in scientific argumentation sequences.

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THE WAY THE HISTORY OF SCIENCE DISCOURSE IS EMBEDDED IN GREEK SCHOOL SCIENCE TEXTBOOKS

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Abstract: The history of science discourse can contribute to two basic aims of science education, those of learning science and those of learning "about science". In the relevant bibliography the main arguments supporting the inclusion of history of science in science teaching are: students are introduced to the contemporary social issues of science and the nature of science; history of science establishes science as a result of human actions; it promotes students' meaningful learning of the subject matter; it improves their attitudes towards science, etc. This work focuses on the way the history of science discourse is presented in Greek lower secondary education (7th-9th grades) science textbooks. The textbooks under study are six: 2 Physics, 2 Chemistry and 2 Biology, as well as the corresponding student's activity packages. The research instruments are a combination of quantitative and qualitative ones. The analysis of the collected data revealed that the discourse of the history of science is limited, fragmented, superficial and in many cases literally marginalized, reflecting the authors' ideological and epistemological views about the nature of science. In most cases the course of scientific endeavor is presented as an ongoing linear progress, being the result of a unique scientific method strictly followed by every scientist. Moreover, science appears to be the product of individual scientists' efforts, while the socio-cultural context in which science is produced is usually overlooked. Finally, almost half of the textbooks reflect the idea that the origin of science lies mostly in the works of Greek philosophers, thus serving the Hellenic national narrative.

Keywords: Science education, Science textbooks, History of science, Lower secondary education

INTRODUCTION

There are numerous arguments favoring the engagement of history of science in science education. Among them is that history of science helps students to learn science, as well as to learn "about science" (Leite, 2002; Wang & Marsch, 2002). Regarding learning science, Galili & Hazan (2000) have pointed out that history of science promotes students' meaningful learning of subject matter, thus helping them to understand the concepts and processes of science (Wang & Marsch, 2002). As far as learning about science is concerned, history of science helps towards humanizing science, improves students' attitudes towards science and helps them to understand the contemporary social issues related to science (Leite, 2002) or to deepen on questions about the nature of science (Niaz, 2000). Also, history of science when focusing on the epistemology of science shows that there is not a unique and specific scientific method, but a number of parameters (goals, interests, motives, etc.) that influence the way scientists work when they "do science" (Chalmers, 1982; Knein, 2001).

Another argument in favor of using history of science in science education is that it can help towards the conceptual change of students' alternative ideas, especially those that resemble to the ones scientist of the past held (Wandersee, 1985; Seroglou et al., 1998, Galili & Hazan, 2000).

On the other hand, school science textbooks are considered to be one of the most powerful educational medium in imposing their meaning on students' minds. They are one of the agents that socialize students (Knain, 2001) and they are institutionally defined. The texts in school textbooks have greater "authority" (Olson, 1989) than other texts open for meaning-making. Each student interacts with the text, and constructs his or her own meaning in the social process of reading. The interpretive power of pupils is limited by the closure and institutional authority of textbooks (Kalmus, 2004). Thus, the way history of science is recontextualized and presented in school science textbooks is very crucial for the construction of the image of science in students' minds.

The purpose of this work is to trace the way the history of science discourse is presented in Greek science textbooks of lower secondary education. Such a discussion may contribute to developing generally accepted criteria in designing future educational texts.

THE GREEK EDUCATIONAL CONTEXT

The context in which lower secondary education science textbooks are functioning in Greece is characterized by: different science areas (physics, chemistry, biology) are taught as distinct subjects (e.g. Physics, Chemistry and Biology) and not in an integrated way (e.g. Science). Moreover, for a specific grade and a specific science subject, only one textbook is authorized by the Greek Institute of Education to be distributed to all Greek students. Thus, the "authority" of these textbooks is great; confining the way students and teachers can interpret the kind of image of science they present. For that reason it is very important to trace the way the history of science discourse interacts with science discourse in constructing the image of science presented in Greek science textbooks.

METHODOLOGY

The research question: To what extent and in which ways is the history of science discourse incorporated in Greek science textbooks of lower secondary education?

There was no sampling, as the research considered all Greek lower secondary education science textbooks, i.e. six (6) textbooks: 2 physics (ph8, ph9) textbooks (grades 8 and 9), 2 chemistry (ch8, ch9) textbooks (grades 8 and 9) and 2 biology (b7, b9) textbooks (grades 7 and 9) and the corresponding student's activity packages accompanying each textbook (Table 1).

Greek lower secondary school						
	Subject			No. of Textbooks (activity packages)		
grades	Physics	Chemistry	Biology	Physics	Chemistry	Biology
7th (12 -13 ys)	-	-	+	-	-	1(1)
8th (13-14 ys)	+	+	-	1(1)	1(1)	-
9th (14-15 ys)	+	+	+	1(1)	1(1)	1(1)

Table 1: Greek science textbooks

The research instruments: The research instruments were a combination of quantitative and qualitative ones. Specifically, a quantitative instrument was developed to explore the status that the history of science discourse posses in Greek science textbooks (Table II). In addition, a part of qualitative instrument developed by Leite (2002) was used to explore the way the evolution of science is presented. The latter one has been enriched by two more indicators (mention of a specific scientific method, and mention of Greek history or mythology) as well as some numerical descriptive factors (Table 2).

RESULTS

All Greek school science textbooks are designed according to a more or less similar pattern (macro-structures). Specifically, they are shaped according to specific modes, like:
A) a core “text”, which is the main source of study for students. The core “text” mainly consists of (micro-structures): a) written texts; b) pictorial (visual) representations (tables, graphs, experiments, etc.); c) questions and exercises and d) activities. All these are considered to be obligatory requirements for the students.
B) a supplement “text” which is considered to be open to any student who would like to be more engaged with issues related to the subject under study. The supplement “text” mainly consists of: a) pictures and captions referring to scientists or technological devices; b) insets referring to interdisciplinary or STS issues; c) colored pages which are used either as an introduction to a chapter, or to present a short science story or to additional activities; d) appendices which in biology textbooks refer to history of science events in chronological order.
In most cases, science textbooks of the same subject have been written by the same group of authors. Only the group of authors for the two chemistry textbooks (ch8 and ch9) is totally different. Head of each group is usually a staff science university member.
The quantitative (descriptive) analysis of the Greek science textbooks in an attempt to trace the presence of the science discourse is depicted in table II. Most rows of the table, especially those referring to the analysis of written texts, present the sum of all references to the science discourse as number of pages and the corresponding percentage (%). However, some others, which refer to the analysis of specific incidents having an autonomy (e.g. images, activities, insets etc.), present the sum of all incidents as number of references and the corresponding percentage (%).

School textbooks and activity packages						
Modes (Macro-structures)	ph2	ph3	ch2	ch3	b1	b2
A) Core “text”						
a) written text no. of pages (% total)	4,5p (2,8%)	5p (3,3%)	0.7p (0,7%)	0,75p (0,8%)	-	2,8p (1,9%)
b) pictorial (visual) representations (tables, graphs, experiments)	-	-	-	-	-	-
c) questions and exercises	-	-	-	-	-	-
d) activities (no. %)	-	-	-	1	1	8
B) Additional – Supplement-Complement “text”						
a) Images (no. % total) (pictures and captions)	14 (5,8%)	27 (8,9%)	8 (4,5%)	3 (2,9%) + 1 a.p. (2,6%)	-	4 (4,3%)

Individual scientists	9	20	7	4	-	4
Technological devices	5	7	1	-	-	-
b) Insets (no. % total) (interdisciplinary issues)	7 (20,6%)	2 (1,4%)	2 (1,7%)	5 (14%)	3 (16%)	3 (20%)
STS	-	1	-	5	-	3
c) Colored pages no. of pages (% total)	-	8 (7,3%)	0,6 (5,8%)	5 (55%)	2 (44,4%)	-
Activities (free)	-	-	3	5	3	-
d) Appendices (pages %) (History of science events in chronological order)	-	-	-	-	4p (100%)	4p (100%)

Table 2: Modes through which the history of science discourse is presented in science textbooks

The qualitative analysis of the Greek science textbooks, in an attempt to depict mostly the ideas expressed by the authors of the specific science textbooks about the nature of science, is presented in table 3. In cases where very few references have been traced, they are specifically and numerically mentioned. In all other cases, the (+) sign denotes a significant percentage of references.

Sub-dimension	Specification	School textbooks and activity packages					
		Ph2	Ph3	Ch2	Ch3	B1	B3
Evolution of science	Type of evolution						
	mention to a science discovery	+	+	+	+	+	+
	description of a science discovery	+	+	+	+	+	+
	mention to discrete periods	+	+	+	+	-	+
	linear and straightforward	+	+	+	+	+	-
	real evolution	-	-	-	-	-	+ (2 ref.)
	mention to a specific scientific method	+	+	-	+	+	+
	mention to Greek history or mythology	+	+	+	+	+	+
	responsible people						
	individual scientists	+	+	+	+	+	+
	group of scientists	-	+ (3 ref.)	-	+ (2 ref.)	+ (1 ref.)	-
	scientific community	-	-	-	-	-	+ (1

							ref.)

Table 3 (part of Leite's table II): Analysis of the type and organization of the historical information

CONCLUSIONS AND IMPLICATIONS

Data analysis (Tables 2 and 3) showed that there are differences among books; the presence of history of science is greater in physics textbooks than in chemistry or biology textbooks but, at the same time and more problematic. However, despite of their differences, the authors of Greek science textbooks in lower secondary education do not consider the history of science discourse as a vital (integral) part of science discourse. They do not seem to consider that it helps students to understand the content of science and the nature of science. This is quite obvious in the way the history of science discourse is distributed in different parts (modes) of the science textbooks. It appears mainly in the supplementary "text", which students may not necessarily study. In addition, its presence is in most cases fragmented, minimal, superficial and out of context, something which is supported by the findings of other researchers too (Slobs & Travers, 1996, as it is cited by Leite, 2002). Thus, instead of being an interpretative tool to understand science it is a decorative element in science textbooks.

Science appears to be the product of individual scientists' efforts, while the socio-cultural context in which science is produced is usually overlooked. The way the history of science discourse is presented (the images of scientists of the past and the rhetoric used) seem to support the idea that they are there to attribute respect to our science ancestors. Of course, it presents the humanistic face of science, but at the same time it imposes a kind of individualism and idealism too. Phrases like "Faraday invented the concept of field", "Coulomb succeeded to answer the question…", "Joule showed that…", Öersted invented by accident that…", "Amber claimed that…", "Rutherford discovered that…" are very common especially in Physics textbooks and are used to verify final results or statements. The authors prefer to use a mathematical approach to reach the final results instead of the path of syllogisms which drove to these results.

The evolution of science is presented as linear and straightforward, without backs and forth's. In all textbooks, a unique and very specific scientific method is presented as the only method which gives answers to every scientific question and which ought to be followed by every scientist. Thus they support a positivistic and, in many cases, a deterministic view too.

In the supplement "text" (insets and colored pages), very often a short science story is presented. This story usually is based in science anecdotes (mythological descriptions of science events), which emerged when rewriting science to support the science narrative. Also, in about half of the textbooks, the origin of science lies mostly in the works of Greek philosophers, thus serving the Hellenic national narrative. In these cases, the majority of chapters begin with a brief history on the specific field, starting either from Greek mythology or from the ancient Greek philosophers and their views on the specific subject. This can be considered as underlying (latent) manifestation of a common ideological theme regarding the pioneering role of the Greek thinkers. There are few cases though, where they present origins from the works of Babylonians or the Chinese thinkers.

Based on the above it seems that the history of science discourse is embedded, in Greek science textbooks of lower secondary education not as an interpretative tool for understanding today's science, but rather as a decorative element serving to support stereotypes and functioning as an authoritative discourse for persuading students to accept final data and conclusions.

Having in mind that in Greece there is only one textbook for each science subject, we understand the great ideological power it has over students' and teachers' minds. Based on the above results, this power is not on the side of science and the nature of science.

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How does the Content-related Quality of Students' Statements Influence the Learning Outcome?

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Abstract: In this study videos of small-group experimentation are analysed with two aims. The first aim is to develop an instrument to analyse the quality of content-related statements in student-student communication. The second aim is to investigate the influence of the quality of content-related statements in smallgroups on the learning outcome. For this purpose, existing video data of a preceding research project on experimental inquiry tasks in chemistry education were reanalysed in a first step.
On basis of this reanalysis the instructions for the smallgroups were revised in order to achieve a higher grade of communication from a content-related viewpoint. The learning effectiveness of the revised instructions was examined in an intervention study (N = 192 students) using video analysis and content-related achievement tests. The results of the intervention study showed that the revised instructions were able to enhance the quality and amount of statements. Furthermore the optimisation of the communication quality led to a higher learning outcome.

Keywords: communication – small-group work – video analysis

BACKGROUND

In typical German science lessons teachers dominate the communication (Sumfleth & Pitton, 1998). The percentage of teachers' speech is about 60-85% in many regular chemistry lessons. It has, however, already been proved that especially student-student communication can lead to a deeper examination of the content (Rotering-Steinberg, 1995). According to this, the student-student communication should be promoted.
This study deals with the student-student communication in smallgroups in order to investigate possibilities to increase the quality and amount of students' subject-related statements. The first aim of the study is to develop an instrument to analyse the content-related quality of students' statements. Furthermore, the influence of the quality of content-related statements on the learning outcome is investigated. Analysing small groups is suitable for this purpose because there is an increased rate of student-student interaction compared to classroom instruction.
Both aims lead to the following research questions:

1. Which characteristics of content-related statements can be found analysing the statements of successful and less successful smallgroups (related to the learning outcome) in scientific inquiry phases?
2. Is it possible to increase the quality and amount of statements by optimised instructions of content-related communication situations?
3. Is it possible to enhance the learning outcome by the improvement of the small group communication?
4. Does the altered communication behaviour persist when the corresponding instructions are omitted?

Studies dealing with the quality of subject-specific communication in small groups and analysing the influence of the quality of statements on the learning outcome are rare. The few existing systems for categorising students´ statements are insufficient to investigate the quality of the statements in detail, as they focus only on single aspects (e.g. von Aufschnaiter, Erduran, Osborne, & Simon, 2008). As a result, a new category system had to be developed. Already existing instruments were considered for the development.

In a first step a measure for the content-related quality of statements was developed. For this purpose an existing category system for video analysis used for describing the complexity of tasks in classroom situations (Neumann, Fischer, & Sumfleth, 2008) was adapted. The category system describes the *complexity* of statements by distinguishing them into *facts, relations* or *concepts*. In addition to this, a model of competence to evaluate the German national educational standards was adapted (Walpuski, Kampa, Kauertz, & Wellnitz, 2008). In this model the complexity is varied systematically to construct test items of a defined difficulty. In addition to the *complexity*, *cognitive processes* (reproduction, selection, organisation, integration) are a second dimension in this model. The cognitive processes define which cognitive demand is needed to solve the task. With this model of competence the achievement of students in paper-pencil test can be described. Since the present project also addresses students' achievement, the basic assumptions of the competence model were adapted for the video analysis. We assume that – in addition to the complexity and the cognitive processes – the correctness of the statements is also relevant for the quality of content-related communication.

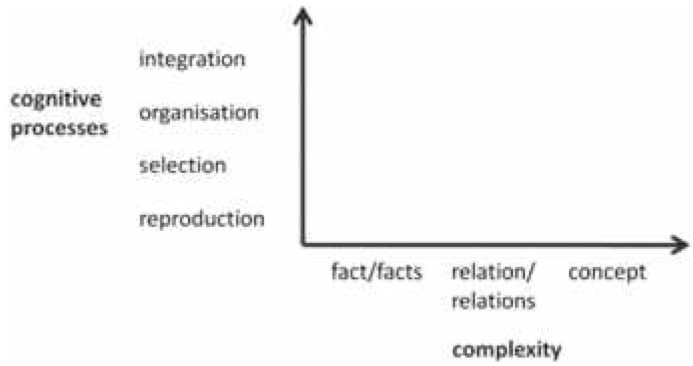

Figure 1: Model for estimating the quality of subject-specific statements (adapted from Walpuski, Kampa, Kauertz, & Wellnitz, 2008)

METHOD

As already mentioned, the study is divided into two parts. In the first step, existing video data of a preceding research project on experimental inquiry tasks in chemistry education (Walpuski, Wahser, & Sumfleth, 2008) were reanalysed to check whether the assumed characteristics for successful and less successful small groups can indeed be found. In this context, success refers to the learning outcome of the small-groups. We assume that successful groups are characterised by more correct statements on a higher level of complexity demanding higher cognitive processes. To test the developed category system 30 videos of 15 successful groups and of 15 less successful groups were reanalysed using the program videograph®. The analysis was used to calculate correlations between the measures from video analysis and performance tests.

Due to the fact that these correlations do not prove any causality or direction, an additional intervention study was needed. For that reason, in a second step, it was investigated if it is possible to increase the quality and amount of subject-specific statements by modified instructions for the small-group work. To prove the causality, additional analyses were carried through as to whether the learning outcome could be enhanced at the same time. A control group did not receive any intervention. In the school year 2009/2010, 48 small groups (4 students each) were videotaped over five lessons.

Table 1: Treatment groups

	lesson 1	lesson 2	lesson 3	lesson 4	lesson 5
control group	unmodified instructions	unmodified instructions	unmodified instructions	unmodified instructions	unmodified instructions
intervention group	unmodified instructions	revised instructions	revised instructions	revised instructions	unmodified instructions

The topic of the small-group work was acids and bases in the 7th grade of secondary schools (high-level). As control variables the cognitive abilities test (Heller & Perleth, 2000) and a test on scientific procedures (NAW) (Klos, Henke, Kieren, Walpuski, & Sumfleth, 2008) was conducted. In addition to this, a test on chemical content knowledge was used (pre-test and post-test) as well as a test on cross-linked content knowledge (triad test). The triad test was used only in the post- and the follow-up-test, because cross-linked was not expected in the pre-test. Additionally, the small-groups were video-taped and in each lesson a short test on content knowledge, referring to the contents of the corresponding lesson, was conducted (see Table 2).

Table 2: design and instruments of the intervention study

pre	accompanying	post and follow-up
• test on chemistry knowledge (Walpuski, 2006) • test on scientific procedures (NAW) (Klos et al., 2008) • cognitive abilities test (Heller & Perleth, 2000) • last grade in chemistry • repetition of classes	• test on chemistry knowledge after each lesson (Walpuski, 2006) • videos 	• test on chemistry knowledge (Walpuski, 2006) • test on scientific procedures (NAW) (Klos et al., 2008) • test on written communication of relations (adapted from Neuroth, 2002)

The intervention and the control groups were balanced based on students´ cognitive abilities and previous knowledge, which were assessed beforehand.

Video analysis

In order to analyse the videos, a category system was constructed. This category system (see Figure 2) contains the correctness and the complexity and cognitive processes.

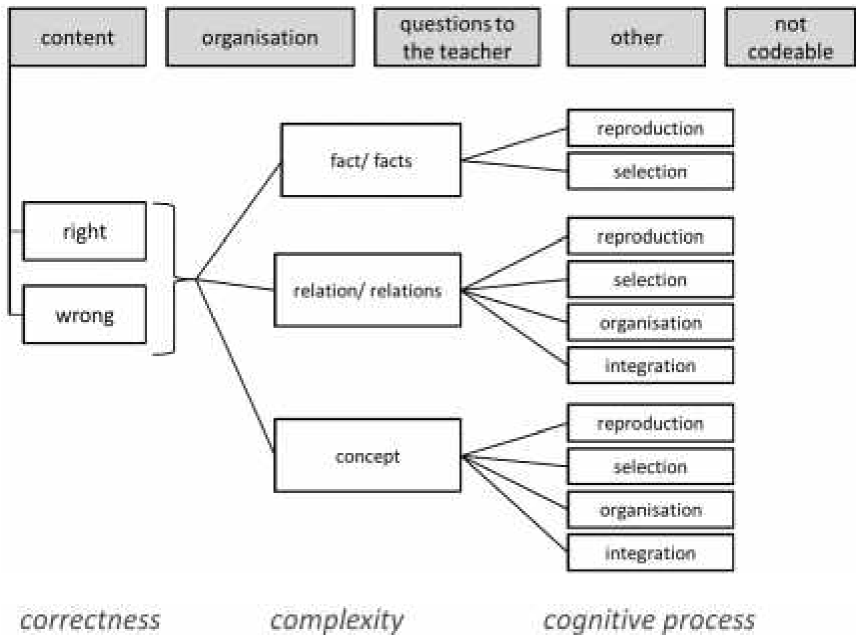

Figure 2: Cut-out of the category system, categories shown in grey, subcategories of the content-related statements in white

To test the category system 10 videos of the reanalysis were coded turn-based by two raters independently using the program videograph®. The category system distinguishes the main categories: content, organisation, questions to the teacher, other and not codeable.
All content-related statements fall into the category *content*. Furthermore, these statements are analysed regarding their correctness, complexity and cognitive processes (see Figure 2). As already mentioned, the complexity describes the amount of information and their linkage, while the cognitive processes define which cognitive demand is needed.
Both the cognitive processes and the complexity are described in the following examples:
Reproduction of fact/facts: “It´s like yesterday, the solution is red.”
Integration of relation/relations: “If the red cabbage juice turns red, when adding hydrochloric acid, then all acid solutions should turn red.”
The first example is classified as *reproduction of fact(s)* because just an observation is described, which the students already know from the previous lesson. The second example is assigned to the category *integration of relation(s)* because it is a generalisation (integration) and an “if-then relation” is stated.
To analyse the characteristics of successful and less successful small-groups, the data of the 30 videos were analysed with the statistical software PASW18 ®. To compare the amount of turns, the number of turns was analysed related to minutes.

RESULTS AND CONCLUSIONS

Results of the reanalysis

In the first step of the study, two trained raters independently coded 10 videos. The results of the interrater-reliability are between $.82 < \kappa \leq .99$. The amount of agreement of the category system can be regarded as very good. The assumed characteristics for successful and less successful small groups were found in the reanalysis. The successful groups state more correct ($p < 0.01$) content-based statements than the less successful groups. Regarding the correct content-related statements only, the successful groups reveal a higher rate of statements in all cases. These differences are significant in the higher cognitive processes on a level of relations ($p < 0.05$ and $p < 0.001$) (see Figure 3). This means that the assumed characteristics for successful and less successful small groups were found in reanalysis in the predicted way. This is also an indication of the validity of the category system.

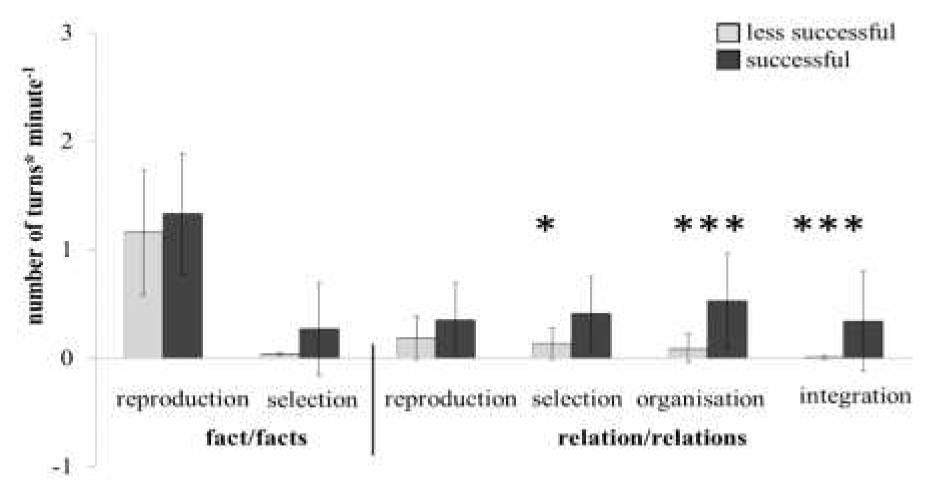

Figure 3: number of turns per minute of the content wise statements, which are correct (mean value+SD)

Results of the intervention study

The sample of the intervention study consisted of 192 students of the 7th grade of secondary schools at a high-level. As some students were not present at the pre or the post-test, only the data from 186 students were used for the pre-post analysis. Furthermore, 7 videos of the 240 videos were not included in the analysis of the video data, because there were only two students in the small-group work present instead of four students or because the audio material was inadequate.

The video analysis showed that there were no significant differences concerning the main categories between the groups. As especially the content-related statements are of particular interest, only the detailed results of the content-related statements will be presented in the following.

The analyses concerning the correctness of the content-related statements show no significant differences, but the intervention group tends to make more correct and less false statements. On a level of facts no differences between the groups could be detected. In contrast, on the level of relations there are highly significant differences for all cognitive processes ($p<0.001$) (see Figure 4). The intervention groups make more statements belonging to the categories *reproduction of relation(s)*, *selection of relation(s)*, *organisation of relation(s)* and *integration of relation(s)*.

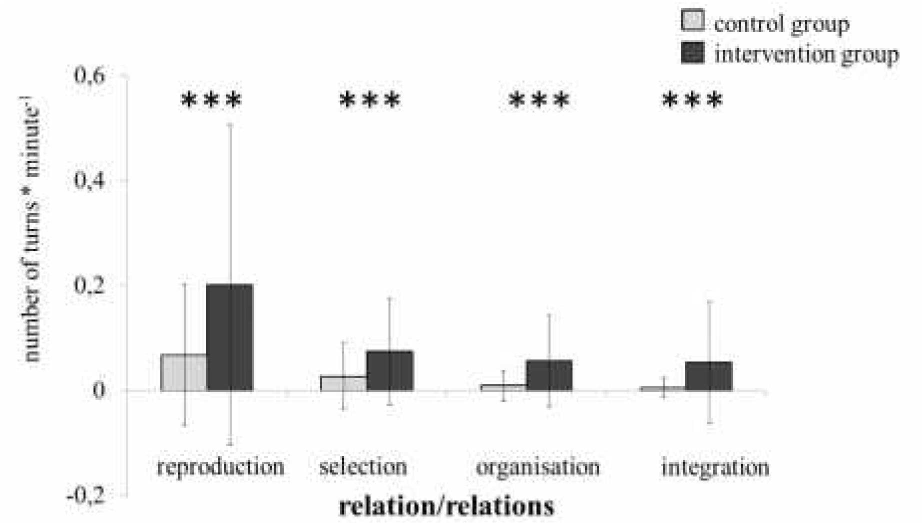

Figure 4: number of turns per minute on a level of relations (mean value+ SD)

Analysing only the fifth lesson, where no intervention took place, there are still differences between both the treatment groups concerning the complexity and cognitive processes of the content-related statements. As shown in Figure 5, the intervention group makes more statements in the categories *reproduction of relation(s)* ($p<0.05$), *selection of relation(s)* ($p<0.01$), *organisation of relation(s)* ($p<0.01$) and *integration of relation(s)* ($p<0.05$).

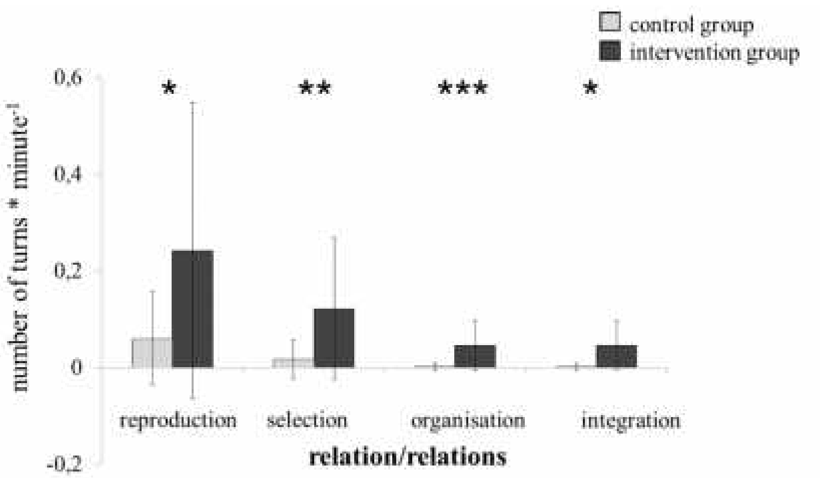

Figure 5: number of turns per minute on a level of relations of the fifth lesson (mean value + SD)

The results of the paper-pencil tests show no significant differences compared to the control group concerning the multiple-choice-test, which tests mainly factual knowledge. But the intervention group is very highly significant ($p < 0.001$) better in the triad test, which tests cross-linked knowledge with open-ended questions.

DISCUSSION AND CONCLUSION

The results of the reanalysis show that there is a close connection between students' learning achievement and the quality of content-related statements in smallgroup work. The assumed communication characteristics of successful groups could be proven by the empirical data. Since these correlative relations cannot reveal any causal direction, an intervention study was conducted. In this study the quality of content-related statements was supported by modified instructions, which were meant to stimulate statements on a level of relations.

The results show that the revised instructions actually increased the quality and amount of content-related statements. The intervention group made more statements of the categories *reproduction of relation(s), selection of relation(s), organisation of relation(s)* and *integration of relation(s)*. Furthermore, the instructions enhanced the more complex cross-linked knowledge. Concerning the factual knowledge, there are no significant differences between the control and the intervention group. Nevertheless, both groups had a significant gain of knowledge. Differences can be shown in the test on cross-linked knowledge where the intervention group performs significantly better. Therefore, it can be concluded that the learning outcome, at least concerning the cross-linked knowledge, can be enhanced by improving the small group communication. Furthermore, in the fifth lesson still significant differences in the amount of stated relation could be detected although there was no intervention. This can be interpreted as a retention effect of the intervention.

Nevertheless, the study enables an insight in the connection of learning achievement and the quality of the stated content. A further benefit of the study is an instrument which ascertains the quality and quantity of content-related statements economically. In practice, the study submits an optimisation of the small-group work with interaction boxes with the topic acids and bases.

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Study of the interrelationship between students' arguments and features of tasks in science classes.

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Abstract: From previous studies we have identified types of arguments that students use when they solve problem-tasks in science classes. In this paper, we will focus on the way the features of the tasks determine the type of argument that students use. It is a qualitative study that gives a deep understanding of students' scientific conceptions, and how students interrelate their ideas with the types of arguments they use in a science class situation of dialogue in small groups. Our analytical framework is mainly based on the Theory of the Argumentation of Perelman, and the schemes for presumptive reasoning of Walton. We will complement those schemes with some of Aristotle's "topoi". With this analytical framework we have analyzed several transcribed dialogues of students during open activities in a secondary school, and recognized the argument and premises that students use in their arguments. A result from our study is that tasks influence the argumentative schemes and the premises used by students in a different, and sometimes unexpected, way. This depends on specific features of the tasks, but also on the personal interpretation that students make, which could be related to their ideas and misconceptions. The process of analysis enlightens our understanding of their science conceptions related to the scientific content, and also important implications for the training of the teachers that can be drawn.

Keywords: Argumentation, Science's Misconceptions; Secondary Education

BACKGROUND, PURPOSE AND FRAMEWORK

Relevant to the aim of our research, there have been attempts to identify general strategies of reasoning that were not related to a specific content of the questionnaire, or the interview commonly used in research about the science conceptions of students (Andersson, 1986; Guidoni, 1985, 1990; Viennot, 1996; Castells & Pintó, 2000). These works contribute our thinking in the way that beneath the specific forms of reasoning of the students, there can be found some common or general ways of reasoning or patterns of arguments or schemes. From those studies, we suppose now that the image we have to have of the science of children can't be as simple as at the beginning of this research line could be supossed and linked not only to ideas or concepts but also related to patterns of reasoning students acquire during their live into and outside the school. In the last decades, numerous studies have focused on the analysis of argumentation discourse in educational contexts; among others, Driver, Newton, & Osborne, 2000; Jimenez-Aleixandre, Burgalló & Duschl, 2000; Zohar & Nemet, 2002; Erduran & Jimenez-Aleixandre, 2007; Buty et Plantin, 2008). In relation to research on argumentation great influence has been contemporary's theories of argumentation, especially Toulmin's (1958), who apart from the theoretical part of his work, has provided with his schematical representation of an argument, which has been a useful and practical tool to analyse and to teach to build arguments in science classes' context. Even less research has been focused on the interrelationship between the conceptual comprehension of the students and their argumentation (Von Aufschnaiter, 2008) despite the fact that nowadays science education agrees to introduce argumentation in science classes and also to foster dialogical attitudes (Scott et Al. 2006) and collaborative capabilities in the students.

The *Purpose* of this work is to study with detail the possible relationship between the argument schemes used by the students in small group discussion often related with misconceptions in science and the features of the qualitative tasks that we propose to them.

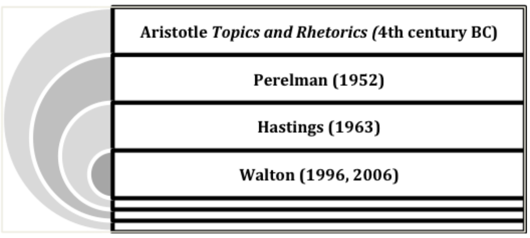


Figure 1

Our *Framework* is mainly based on the Theory of the Argumentation of Perelman (1952) and completed with the schemes for presumptive reasoning of Hastings (1963), Walton (2006, 2008) and with some of Aristotle's "topoi" (III BC). (figure 1)

The mentioned authors; provide argument schemes and types of premises, which we expect to find in the discussions with the students, considering that their arguments are mainly not deductive, but of presumptive nature. These theoretical bases come mainly from the field of Philosophy and they have not been used in science education research, except for few studies (Jimenez-Aleixandre, 2003; Duschl, 2008; Author et al., 2007; Fagundez & Author, 2008; Author, Erduran, Author, 2009 According to our perspectives, we consider an argument consisting of a thesis, one or several premises, and the scheme that allows the transference of the accepted premises to the thesis or conclusion (figure 2).

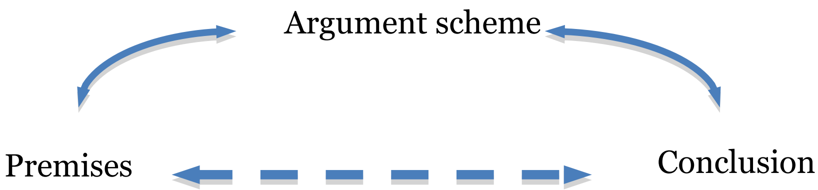


Figure 2

RATIONALE

The general approach of this work is to use the argument schemes as an instrument to understand the ideas and conceptions of students through the analysis of the structural part of the arguments, and identifying in which schema the argument is based on. With our proposal, the previous scientific ideas and conceptions of the students that, of course, has been studied during the last decades in a lot of detail in the research field of science education and psychology, are reanalysed with an argumentation focus approach, capable to characterise the types of arguments and their structural elements which are mainly used by the students, and to better understand the difficulties of the conceptual change of students, as we did in our work presented at ESERA 2009.

In this study, we go further, and in a qualitative and deep way, we try to enlighten the interrelation among fundamental elements in the conceptual development of students that will take up in a dialogical setting of science classes: features of the problems-tasks we propose to students, previous scientific ideas that students have, personal interpretation of the situations of the tasks and the argumentation schemes used by the students performing the tasks in small group. We can summarize the research questions as:

-What types of argument schemes and premises could be found in arguments of the students? Are they related to these specific tasks?
-Which features of the tasks are more relevant for its influence on the argument schemes and premises used by students and in which way?

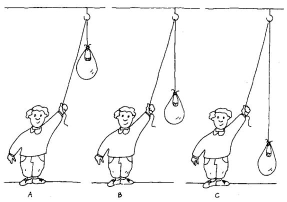
-Which is the ‘role’ of the students’ interpretation (“visions”) of the situation presented in the task in relation with the arguments given by them? Which is the relationship between these interpretations (“visions”) and previous scientific ideas of students?

METHODS

Instruments and Sample

Four qualitative and open tasks are proposed to several small groups of students in two classes of compulsory secondary education (12-13 years old and 14-15 years old) in a public school in the metropolitan area from Barcelona. The tasks are about: *Forces related to a body holding by a pulley arrangement, Floating and sinking and Climate change; Heat conductivity* and *Galilean Relativity of motion*.

Table 1. The proposed task

Description of the task	The tasks
1. *Conceptions about forces related to a body holding by a pulley arrangement* Students have to answer if the force the child has to do is the same or different at the different positions.	In which of the three situations A, B o C the bag weights more? Why?  (adapted from Guidoni, 1990)
2. *Floating and sinking and Climate Change* A physics and social problem is presented in the form of 3 slides, one after the other with the three questions presented here.	 1. What will happen to the level of the water when the ice melts? Why? 2. Does your prediction agree with the result we show below? 3. Scientifics agree that because of the increase of temperature in the Earth as the main cause of (because) the climate change, the level of the sea will increase. Could you compare this prediction with the result of the previous experiment? If the prediction of the scientifics is correct, how do you explain this prediction taking in consideration the previous experiment of the glass and the ice?
3. *Heat conductivity* A comic presents three different children’ ideas/arguments. Students have to chose with which one they agree and why.	 With which child do you agree and why? 1. Don’t put the coat on the snowman. It will melt him 2. I don’t think that the coat will make any difference 3. It will keep him cold and stop him melting. (Osborne et al. 2004 IDEAS)
4. *Galilean Relativity of motion* A physics problem in the context of a river is phrased in a way encouraged student to see the situation from the frame of reference in motion (river). Students have to take a decision between two possible actions in relation to a two floating boxes in a river	Imagine that you are floating on a tyre in the middle of a river and not swimming. Some metres upstream there is a wooden box floating and some metres downstream is another wooden box. a) If you are floating, not swimming, will the distance between you and each box change with the time? Why? b) Imagine the tyre no longer holds you up. Which of the two boxes would you reach first? Why? (Castells, 1997)

Students neither received any instruction about argumentation nor the scientific content of the some of the proposed tasks. After writing the answer individually, students discussed in a small group (3 or 4 students) about their proposed answers and about the reasons or arguments of their answers. The dialogues were voice recorded and then transcribed.

The Analysis

The analysis mainly consists of looking for arguments in the transcribed dialogues, identifying thesis, premises and argument schemes. From our theoretical framework, we elaborate a primary list of argument schemes, and types of premises, which are our initial analytical framework. With this framework, we recognise the argument schemes and premises that students use in their arguments. From this analysis, we enlarge our initial list of schemes, using some schemes from Walton (2006, 2008), Hastings (1963) and Aristotle's Topics.
The list of argument schemes that we used is given to the following table.

Table 2. Definition of argument schemes of our analytical framework

Argumentation scheme	Definition
1. **Double Hierarchy argument (DH)** (Argumentation scheme of Perelman and Olbrechts-Tyteca 1969, p.337)	Arguers that use the double hierarchy strategy take an established series or hierarchy, one accepted by or at least familiar to an audience, and form a second series on the model of the first, in the process trying to transfer implications of order or value form the first to the second DH. DH normally expresses an idea of direct or inverse proportionality, or at least a term- to–term relation.
2. **Example/Illustration** (Argumentation scheme of Hastings, 1963, p.25) (Walton, 1996, p. 50) (Perelman and Olbrechts-Tyteca 1969, p.350)	In this scheme, the essential characteristic is the verbal formulation of a description of an aspect of reality from the presentation of typical instances, examples, or samples of reality.
3. **Quasi –logical Arguments** Argumentative scheme of Perelman & Olbrechts-Tyteca (adapted from Warnick, 1999)	They are classify Quasi-logical by comparing them to formal reasoning, with which they have something in common, but they lack of the rigor and the preciseness of logical ones.
4. **Expert opinion- From Authority (Testimony)** (Argumentation scheme of Hastings, 1963, p. 126) (Walton, 1996, p. 64)	In using this argument from authority the speaker supports his conclusions directly by presenting an authority who asserts that the conclusion is true: The process is, in effect say "X says that this is true or advisable, etc., and therefore we can infer that it is true or advisable, etc
5. **Argument from Sign to an Unobserved Event** (Hastings, 1963, p.55) (Walton, 1996, p.47)	One known even is taken as an indication of the existence of an unobserved event, attitude, state or condition. From the fact of the occurrence of the first event, the conclusion is that the second event is or was present.
6. **Argument from analogy** (Perelman and Olbrechts-Tyteca 1969, p.371) (Hastings, 1963, p. 111) (Walton, 1996, p.77)	To support a conclusion, a comparison is made between the situation under consideration and another situation. The second, analogical event is similar not on the basis of facts or circumstances, but on the basis of abstract principles; the structure of the abstract relationship of the two events is the same. The conclusion, which is drawn about the analogical event, is applied to the topic situation.
7. **Argument from correlation to cause** (Walton, 1996, p.71)	Infers a causal connection between two events from a premise describing a positive correlation between them.
8. **Argument from consequences** (Walton, 1996, p.73)	Practical reasoning in which a policy or course of action is supported or rejected because the consequences will be good or bad.
9. **Argument of ends and means** (Perelman and Olbrechts-Tyteca 1969, p.273)	Some ends appear desirable because the means to realize them are created or become easily accessible. In other words, some ends appear all the more desirable, as their realization is easy.

Process of analysis

The process of analysis with more detail consists of three steps:

- First Step: We look for arguments in the transcribed dialogues**, identifying** thesis, premises and argumentative schemes. (Due to lack of space we omit here the examples)
- Second Step: From our theoretical framework, we **categorize the argument schemes** and premises that students use in their arguments. (From this analysis, we can enlarge our initial list of schemes). (Table 3 presents some examples to illustrate our categories)
- Third Step: We try to **relate** the above categories with the special features of the problem and students' conceptions.

Table 3. Examples of students' argument schemes

Argument scheme	Example
1. **Double Hierarchy argument (DH)** *(Task 2)*	Student*: "... the surface of the raft is not sufficient to support the weight of the mammoth on the water. (...) Our solution is to increase the surface of the raft on contact with water (length and width), but not in height. The more surface has the raft, more weight is able to withstand the mammoth..."*
2. **Example/Illustration** *(Task 1)*	Student: *"In theory the sack weighs the same, but since it's nearer to the earth it weighs more, isn't it? It's as for example* ***you take the sack to the moon, we would say that there it weighs less, but it still has the same mass****. So, I would say that the sack weighs more. What happens is that the mass sis the same, but being nearer to the earth, the gravitational force is bigger."*
3. **Quasi –logical Arguments** *(Task 2)*	Student: *"I think that the water level will stay the same, because when the ice is first added to the water, displacement takes place forcing the water level to rise. As the ice melts this would counteract the displacement, but obviously the melted water would add to the volume, therefore creating a neutral effect where the water level would stay the same."*
4. **Expert opinion- From Authority (Testimony)** *(Task 1)*	Student:*"I think that when the ice melted the level of the water will increase a little because in the News at TV they say that the level of the sea will increase because the climate change."*
5. **Argument from Sign to an Unobserved Event** *(Task 3)*	Student*: When you put a coat on a snowman, then coat becomes wet, that means that the snow melts in the coat.*
6. **Argument from analogy** *(Task 3)*	Student: *"I think that the boy that is right is the third one: " It will keep it cold and stop melting it". To us (people), the coat works to keep body's temperature and not get cold; so, it will happen the same to the snowman."*
7. **Argument from correlation to cause (Walton, 1996, p.71)** *(Task 2)*	Student*: "...And more, the climate change makes that the heat arrive before and makes that the trees produce flowers before and that in February the allergies begin because of the pollen although they would have to begin at the end of March.*
8. **Argument from consequences** *(Task 1)*	Student: "*I think if the river flows down, I would go towards the box below, because it would help me also to go down. The current of the river goes down and thus it helps to go faster."*
9. **Argument of ends and means** *(Task 1)*	Student: "*I think that of the river has a current down stream, I would have done towards the bow that is downstream… because it would help me to go downstream*".

Following, we present two fragments of transcriptions taken from one of the proposed problems in order to illustrate one aspect of the analysis, the importance of student personal interpretation of the situation of the task.

Transcript task boy supporting a bag by a rope	Personal interpretation of students
Student 1: … *I think it weighs the same because it is the same bag, except in the beginning he can hold it better because he feels stronger and finally he get tired a bit with the bag and that's why the bag is lower.* Student 2: *I agree that in A the bag weights more*	Student's 1 interpretation is based on the tiring subjective sensation that means a possible personal effect related with the view of the three pictures as a process A→B→C. Student's 2 interpretation is based on the position of the bag and its distance with the

because the further up the force of gravity the greater it tends to go down, and that's why the boy stretches it more...	ground. (geometrical view)

The majority of the students answer correctly the question about the weight, but they add comments about the force that the boy has to do that depend on their personal interpretation of the task.

Different interpretations of the task 1

1.**They "see" the different distance with a ceiling or the floor in the three drawings.**
The main types of argumentation schemes that are used in this interpretation is DH arguments.
In this interpretation, students' conceptions have mainly to do with "gravity increases with height" and "gravity decreases with height".
2.**They "see" the three drawings as a sequential process**
The main type of argumentation scheme that is used in this interpretation is the DH argument, taking account the parameter of time.
3.**They "see" the existence of a pulley**
The main argumentation scheme in this case is ends and means (the pulley facilitate the process)
4.**They "see" the length of the rope**
Argumentation scheme: DH arguments that relate the more rope with the weight.

RESULTS

We have found that the tasks influence the type of argument-schemes by different ways. They depend on features of the task, as well as on the personal interpretation of student of this, related to the way we present the task, and sometimes also related to their misconceptions, intuitions or personal or common experience. Among others, we have found several features influencing the argumentation of the students in specific ways such as:

- The proposed problem contains given arguments that can favour their use in the argumentation of the students. (Case of the snowman task 3)
- The problem offers a situation about which students have to take the most convenient decision related to a possible physical action that they could carry on. This type of problem can foster types of argument schemes by consequences or linked to an anthropocentric focus, e.g. personal physical feelings. (Case of the task 3 and task 4)
- The problem has a statement that allows a geometric point of view (a drawing as in our example), arguments are strengthened with geometric assumptions that foster some specific schemes or premises (e.g. can use the premise that the weight depends on the distance with the ground). (Case of the task 1)
- The situation of the problem presents an object that is considered to have a specific functionality (e.g. the function of a coat), the task can be viewed and argued from the standpoint of this functionality (as we have seen in the example of heat transfer with the snowman covered with a coat)
- The possible relationship of the proposed tasks to any science law or theory studied in school or in the textbooks that brings to the student's application of that law or theory to interpret the situation of the task. (Case of task 1).
- The possible relationship of the proposed tasks to any scholar o from the media experiment and the interpretation that student give of that experiment. (Case of task 1and 2)

In summary, our results have shown us that the more points of view that can be adopted by our task, the larger the variety of arguments can be given by students. This is always linked to the knowledge of the student, either established by science (e.g., gravity/distance to the centre of the Earth) or intuitively (e.g., the boy feels stronger). These last types of tasks will be the most appropriate if the teacher wants to teach in a class with dialogical discussion.

CONCLUSIONS AND IMPLICATIONS

From this and earlier studies, we are improving our understanding of students' arguments in relation to science conceptions. For science education the result from our research about the interrelationship between the four elements identified by means of the analysis (features of the problems-tasks, previous scientific ideas students have, personal interpretation of the tasks' situations and the argumentative schemes used by the students performing the tasks in small group) is very relevant. As our research is limited, further studies are needed about argument schemes that students use in science classes to improve our comprehension of students' conceptions in science and also our knowledge of common sense argumentation. An implication of our research could be to include not only students' misconceptions in teachers' training programs but also the most common students' argumentative schemes for deeper understanding of their reasoning. This is important because the teachers will be able to use these argument schemes in their dialogical classes as a "tool" to favour the process of learning science and to provide "clues" to help them to choose appropriated activities in science education.

ACKNOWLEDGEMENTS

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TEACHING SCIENCE IN THE MIDST OF FUZZY DISAGREEMENT: A STUDY OF ARGUMENTATION IN A CLASSROOM

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Abstract: In this study, in order to learn about a novice teacher's practices in argumentative contexts, we examined discursive interactions in a science classroom. We intend to contribute to research on *processes* involved in supporting science learning through argumentation. A naturalistic design utilizing qualitative research methods and interactional ethnography was employed to investigate two research questions : In what aspects argumentation differs in various instructional contexts of a science classroom?; How a science teacher uses language in different argumentative contexts in the classroom?. The main data sources were: participant observation conducted during 8 months, field notes, audio and video records of science lessons, 3 interviews with the teacher. Pragma-Diale ctical theory of argumentation was adopted to analyze data. The results show differences in argumentation among episodes from various instructional contexts in relation to: relationships among the differences of opinion; nature of the differences of opinion; structure of the argumentation; roles of participants; and whether argumentation components were made explicit or were implicit during discursive interactions. The teacher's language use varied in two aspects: how he raised questions and how he made explicit/implicit his points of view. Teacher's discursive strategies were influenced by his goals as well as relationships between students' knowledge and scientific school knowledge.

Keywords: Argumentation; argumentation theory; teaching practices; science learning

INTRODUCTION

Seeking to better understand how knowledge is socially constructed in classrooms, educational researc hers have turned to the study of discourse in school context. Some of the implications of this perspective are that language is perceived as mediational mean for thinking, and that the role of the teacher is of a "language user" who supports conceptual understanding (Edwards & Mercer, 1987). Researchers and policy makers consider argumentative discourse as essential in science learning (e.g., Driver, Newton, & Osborne, 2000; JiménezAleixandre & Erduran, 2007; NRC, 2000; Sadler, 2006; Sandoval & Milwood, 2007; Schwarz, 2009; Scott et al., 2007; Zohar, 2007). Nevethelless it was only relatively recently that the relationship between learning and argumentation became focus of research in science education (Andriessen , 2006; Baker, 2009; Chinn & Osborne, 2010; Schwarz, 2009). Moreover, although scholars acknowledge the significance of teaching when trying to understand learning, there are still few studies on aspects of teachers' practice in argumentative contexts and how they can impact learning (e.g., Avraamidou & Zembal-Saul (2005); McDonald, 2010; McNeil & Krajcik, 2008; Osborne, Erduran & Simon, 2004; Sandoval & Reiser, 2004; Venville & Dawson, 2009; Zembal-Saul (2008). Finally, frequently, the studies focus on the quality of arguments produced by students or teachers, not in *how* people argue to reach some agreement.

In this study, to learn about a novice teacher's practices in argumentative contexts, we examined discursive interactions in a science classroom. We intend to contribute to research on *processes* involved in supporting science learning through argumentation. We investigated the following research questions: 1) In what aspects argumentation differs in various instructional contexts of a science classroom?; 2) How a science teacher uses language in different argumentative contexts in the classroom?

METHODS

Research Setting

The study took place in a middle school science classroom for adult learners in a night shift school, which was part of an outreach university project. We acknowledge the existence of adult learners' particulatities, but we believe that some of these characteristics have parallels in children and teenagers(e.g., conflicts between everyday knowledge and scientific knowledge). Thus, studing adults can contribute to a better understanding of science learning in general – as has been argued for other non mainstream groups.

The teacher, Mr Sunday, had graduated very recently, but worked as teacher for about two years before data collection. He was very committed to promoting students' learning, and he was very attentive to learners' demands. Although he often teached through lectures, he interacted a lot with students, mainly due to his abilities in encouraging them to participate and in posing questions to check understanding.

Methodological Orientations

A naturalistic design utilizing qualitative research methods (Lincoln & Gubba, 1985) was employed in the present study. It can be characterized as a case study (Stake, 2000; Merriam, 1998), informed by interactional ethnography (Castanheira et al.,2001; Dixon & Green).

Many studies on argumentation in science education had used Toulmin's model as a methodological framework (Driver et al., 2000; Erduran, 2007), they usually have as focus the quality of the argument/argumentation and characteristics of their different components. In our study we chose to use the Pragma-Dialetical theory of argumentation (Van Eemeren *et al.*, 1996, 2002) to learn about *argumentation processes* in learning contexts. We focused on teacher's moves throughout argumentation, and the procedures involved in resolving differences of opinion, always considering the broader context in which argumentative interactions took place.

Data Collection

During eight months, the second author conducted participant observation (Spradley, 1980) with narrative recording in field notes, combined to audio and video recording (Green et al., 2001). Following a contrastive perspective (Castanheira et al., 2001), in this study, we focused on episodes from three lessons with different characteristics (see Table 1). We also conducted three two-hours long interviews with the teacher to have insights into participant's perspectives. Finally, we had access to teacher's written records about the lessons.

Table 1: Major characteristics of the lessons

	LESSON 1	LESSON 2	LESSON 3
Theme of the lesson	Blood types (ABO): antigens/ antibodies	Choosing units to measure solid waste	Ecological Relationships between living beings
Instructional context	Lesson is part of a series of lessons that address Circulatory System	Lesson is part of an inquiry unit on solid waste	Lesson is part of a series of lessons on ecological interactions.
	Lesson is conceived to prepare students for a Lab Activity	Lesson is conceived to prepare students for collecting data on their own waste	Lesson is conceived to prepare students for reading a book on Ecology and doing a group presentation.
Learning focused on	Scientific Concepts	Scientists Practices	Scientific Concepts
Differences of opinion involving…	Students' knowledge versus School Science knowledge	Teacher's and students doubts	Different points of view from School Science knowledge

Analyses

The first phase of analysis involved transforming audio and video records into some type of written or graphic representation of data (Cameron, 2001). We used tools from Interactional Ethnography such as event maps and story lines with different grain-size (Castanheira et al., 2001; Green & Dixon, 2005). Through this analysis it was possible to identify key-events involving argumentation related to learning scientific inquiry practices. A total of 7 episodes (each lasting from 5 to 20 minutes) were transcribed word-by-word.

Initially, the transcripts were analyzed having as major reference the "analytic overview" framework and evaluation procedures from Pragma-Dialectical theory of argumentation (Van Eemeren et al., 1996, 2002). This theory combines aspects of discourse analysis, rhetorics and dialectics to analyze argumentation. We focused on i) identifying points of views, and establishing what were the main and subordinate differences of opinion, and whether they were explicit or implicit; ii) identifying protagonist or antagonist positioning; iii) characterizing the structure of arguments. In addition, to better understand the context of interactions we went back to video records, field notes, interviews and teacher´s classroom records.

Moreover, based on Van Eemeren and colleagues' work, we developed three different types of representation to better visualize how arguments were constructed through interaction and how argumentation differs in the various contexts: i) representing relationships between argumentation components and discourse (Figure 1); ii) representing the whole structure of argumentation in detail at the end of the episodes, considering the multiple points of view at stake (Figure 2); iii) representing the whole structure of argumentation, but in a way that makes visible broader characteristics of argumentation in the episode (e.g., the relationships between main and subordinative differences of opinion) (Figure 3).

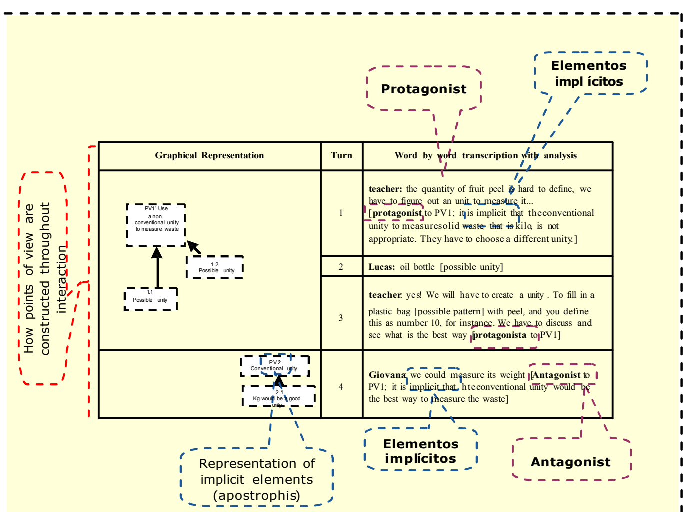

Figure 1: First type of representation created to use Pragma-Dialectics in classroom-based studies of argumentation. It is generated *during transcript analysis* with the goal to establish direct relationships between participants' talk and elements of argumentation (points of view and supporting elements) and how they are constructed through time.

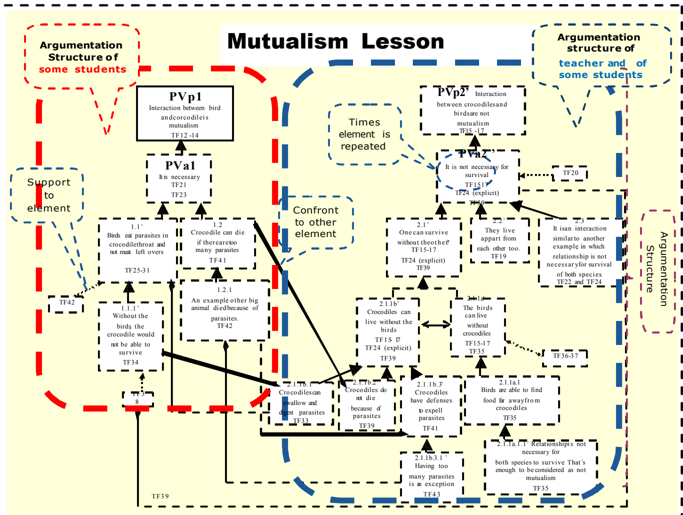

Figure 2: Second type of representation created to use Pragma-Dialectics in classroom-based studies of argumentation. It is a summary of results of transcript analysis. It makes it possible to identify points of view and supporting elements of argumentation, as well as provides evidence on how (and by who) arguments are generated in interaction.

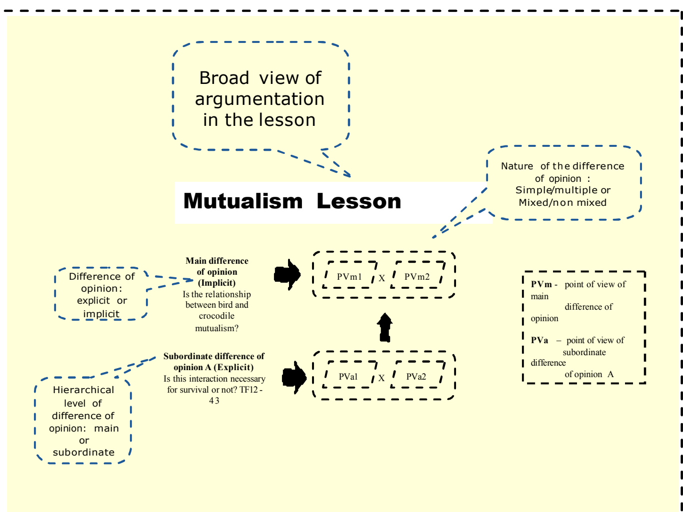

Figure 3: Third type of representation created to use Pragma-Dialectics in classroom-based studies of argumentation. This representation makes it possible to characterize the broad structure of Argumentation, that is, the hierarchical relationships between major difference of opinion and secondary differences of opinion.

Results

The results show differences in the nature of argumentation in the three lessons. In the “Blood Types” lesson we identified greater complexity in the *relationships between differences of opinion*. In this lesson, there was one main difference of opinion and two *levels* of subordinative differences of opinion. In each level, we identified two differences of opinion. In sum, the argumentation in lesson 1 involved complex hierarquical relationships among the various differences of opinion (Figure 4).

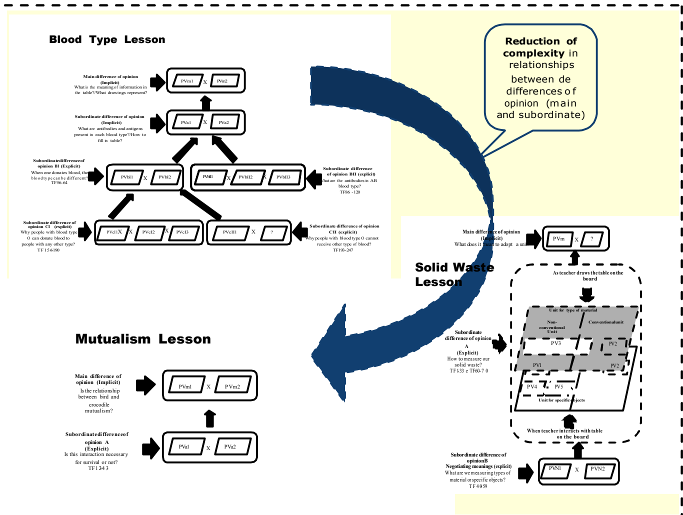

Figure 4: Representations of hierarquical relationships between various differences of opinion in the three lessons. The contrast shows that there is a greater complexity in these relationships in the Blood Type Lesson.

In the Solid Waste Investigation lesson we identified greater complexity in the *nature of the difference of opinion*. In the subordinative difference of opinion more than one proposition was under dispute *and* involved various points of view (Figure 5). Moreover, there was a process of reformulation of these points of view and search for conciliation between them. Maybe this complexity is related to the fact that the teacher was not sure about the answer to the problem posed.

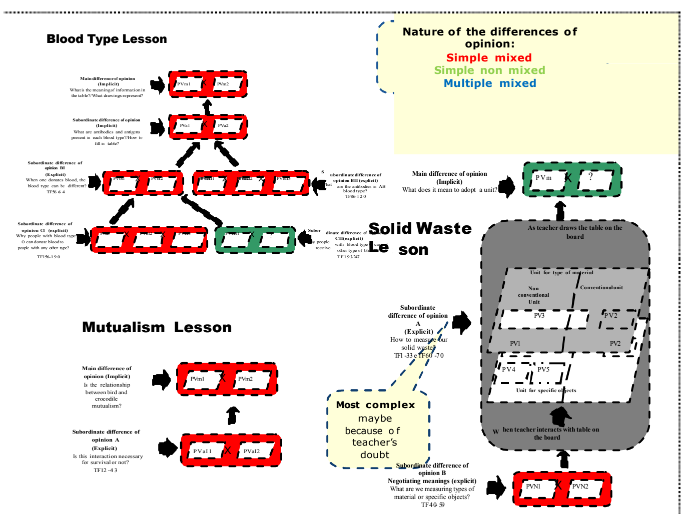

Figure 5: Nature of differences of opinion in the three lessons. The contrast shows that differences of opinion had a more complex structure in the Solid Waste Lesson, that is, in a inquiry based unit when the teacher was not sure about how to answer the problem that was posed.

Finally, in the "Ecology" lesson, we identified greater complexity in the *argumentation structure*. In this case, Mr. Sunday´s argumentation was multiple, subordinative and coordinative (see Figures 6 and 7 for a contrast between the three lessons).

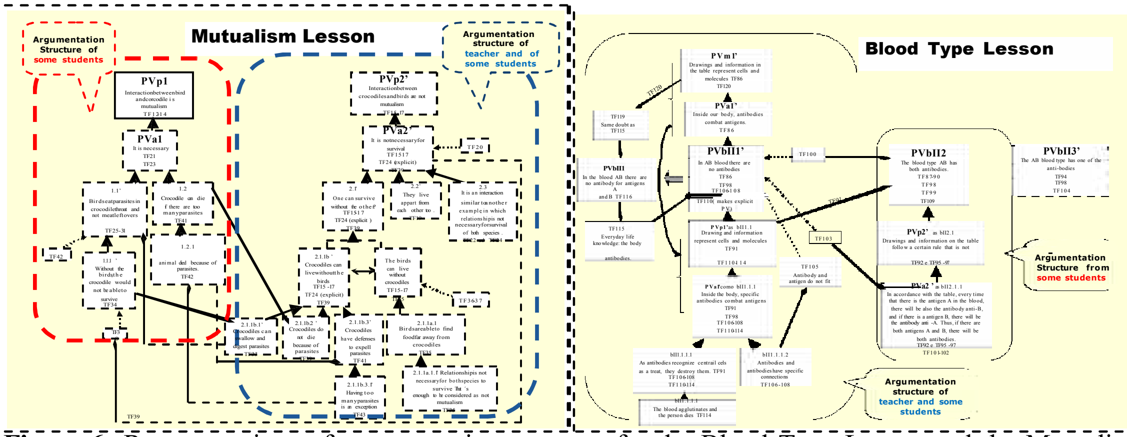

Figure 6: Representations of argumentation structure for the Blood Type Lesson and the Mutualism Lesson. The contrast between these two lesson shows difference in the structure of students' argument, which is more complex when they share scientific ways of reasoning and have greater domain of subject matter knowledge.

In all the three lessons, Mr Sunday tended to act both as protagonist of his own point of view and as antagonist of others' point of view. An exception is in lesson 2, when he had doubts about what was the best unit to be used to measure organic solid waste. In this case, he defended multiple points of view, acting as protagonist and antagonist of them. The students, on the other hand, tended to act only as protagonists of their points of view.

The premisses involving the differences of opinion (main and subordinative) in lessons 1 and 3 are, in general, implicit. Only in lesson 3 the main difference of opinion is explicit, making it possible, for the participantes to be conscious of what is issue leading to desagreement.

We idenfied a significant variation in Mr. Sunday's language use in two aspects: how he raised questions and how he made explicit/implicit his points of view or his arguments. Our analisys indicated that teacher's discursive strategies were influenced by the goals of the teacher, as well as the relationships between students' knowledge and scientific school knowledge. Another interesting aspect of Mr. Sunday's practice was that, through language and with a single uterance, he simultaneously kept discussion open and oriented discussion to a closure.

Implications and Conclusions

Our study supports the notion that argumentation occurs in science classrooms in different forms depending on the context and certain aspects seem to be particularly influential. It also indicates that teachers can develop strategies to teach science in argumentative contexts, using language in various forms. Finally, this researchalso makes evident that the field of Theory of Argumentation can contribute to the development of new methods to investigate argumentation and science learning.

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CLASSROOM DISCOURSE TYPES AND STUDENTS' LEARNING OF AN INTERACTION DIAGRAM AND NEWTON'S THIRD LAW

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Abstract: The purpose of this case study was to describe what kinds of classroom discourse types transfer teachers used and any variations in discourse types when teaching an interaction diagram and N3 law. A further aim of this study was to ascertain whether there was any relation between the variation in classroom discourse types and student learning outcomes for the interaction diagram and N3 law. The teaching sequence in the context of force and Newton's third law was designed and implemented by three transfer teachers (teachers who had not participated in designing the teaching sequence) in three Finnish upper secondary schools. The lessons were video-taped and the most important episodes of the lessons were transcribed. Student learning was monitored with a pre-test and three post-tests**.** The discourse types, duration of discourse types, and the content and purpose of topics in the selected episodes were analysed with a visual tool specifically developed for this purpose. Our main findings suggest that the familiarity of the teachers with the content may influence the variation of discourse types. The results also provide some evidence that variation of classroom discourse types may also support students' learning. The findings of this study have implications for teacher education and education research with the introduction of a visual tool developed for analysing classroom discourse.

Keywords: Classroom discourse, interaction diagram, Newton's third law, learning, transfer teacher

INTRODUCTION

Many studies, especially over the last decade, have furthered understanding in the role of discourse in science teaching and the different characterizations of classroom discourse (e.g. Furtak & Shavelson, 2009; Mortimer & Scott, 2003; Scott, Mortimer & Aguiar, 2006; Viiri & Saari, 2006). As different classroom discourse types serve different purposes, any teaching sequence should include a variety of discourse types (Mortimer & Scott, 2003; Scott et al., 2006). According to Mortimer and Machado (2000), the variation of the discourse type between authoritative and dialogic discussion is dependent upon the teaching purpose and aims, with different types of discussion being used accordingly. The study of Furtak and Shavelson (2009) gives some empirical support that the variation of discourse types builds students' conceptual change: teachers of students with higher learning gains were more likely to vary the kind of guidance (authoritative or dialogic) they provide for students than the teachers of students with lower learning gains. According to Scott (2008), the appropriate discourse types developed by the teacher have the potential to motivate students and to draw them into the science contents. This brings about a need for a pedagogy which is based on purposeful shifts in discourse types as well as a need to develop methods to study these shifts.

In this case study we are interested in the types and the variation of types of classroom discourse in the teaching of an interaction diagram (ID) and Newton's third law (N3 law). This study is part of a wider study that is investigating the use of an ID and how it supports the learning of concept of force in the case of transfer teachers; by this we mean teachers who implement the teaching sequence but are not involved in designing the sequence or lesson materials. The use of transfer teachers offers an opportunity to study classroom discourse in normal school settings; there are not many studies involving transfer teachers (Leach & Scott, 2002).

Interaction diagram is a symbolic representation of interactions where the components of contact and distance interactions are visually identified (Fig 1). The common view among students is that forces are understood as properties of objects. The ID provides a tool to identify and represent interactions between objects, and thus helps students to perceive forces as the property of an interaction instead of a property of an object. There are evidence from studies conducted by Savinainen, Scott & Viiri (2005) and Hinrichs (2005) that the use of an ID enhances student understanding of the force concept. In this study we use the ID presented by Hatakka, Saari, Sirviö, Viiri & Yrjänäinen (2004) as it includes writing down the interactions in terms of pushing and pulling, and is also used in the physics textbook used in the teaching intervention of this study.

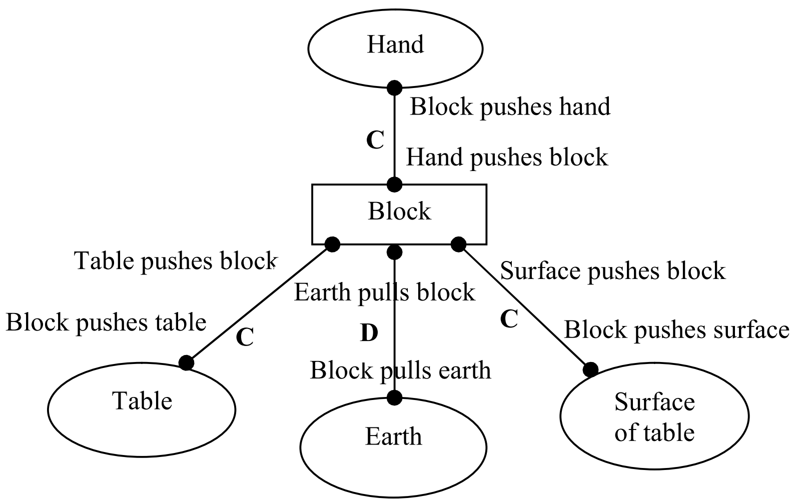

Figure 1. An example of an interaction diagram in the case of a hand pushing a block on the surface of a table. C = contact interaction and D = distance interaction.

PURPOSE OF THE STUDY

The purpose of this study is to 1) describe what kinds of classroom discourse types transfer teachers used and whether there was any variation in the discourse types in teaching the ID and N3 law, and 2) to find out if there is any relation between the variation of classroom discourse types and learning outcomes for the ID and N3 law.

Here the classroom discourse in physics teaching is examined by taking account of the purpose and context of teaching and students' learning of the content. In this study the research methods are developed in a way that the relationship between time, variation of classroom discourse types, purpose of teaching and students' learning can be expressed.

METHODS

This study is part of a wider study where an instructional teaching sequence in the context of force and Newton's laws was designed and evaluated. The teaching sequence (designed for 5 lessons of 45 minutes) was implemented by three transfer teachers in three Finnish upper secondary schools and was included in the introductory physics course that is compulsory for all upper secondary school students. In the introductory course the concept of force is taught for the first time in upper secondary school. The schools participating in the study were named T1 (25 students), T2 (27 students) and T3 (23 students). The lesson material designed for the teachers included teaching contents, timetable, examples, exercises, demonstrations and homework. All three teachers also followed the contents of the same physics textbook (Hatakka et al, 2004). The lesson material and the textbook supported each other by introducing forces as interactions and by using IDs. A more detailed description of the lessons is available in Savinainen, Mäkynen, Nieminen & Viiri (2011).

For the classroom discourse analysis, the primary data source was video-recorded lessons. Some important episodes were also transcribed in order to make the purpose of teaching more evident. The video material was analysed by using the Atlas.ti and Excel softwares. The episodes chosen for detailed analysis included the teaching of the ID and N3 law for the first time. These contents were also dealt with in other parts of the lessons, but teaching was mostly dealing with written tasks (the same tasks in all three schools), and the variation of discourse types in dealing with these tasks was about the same in all schools.

To make the purpose and variation of classroom discourse more evident, the discourse types, duration of discourse types, and the content and purpose of topics in the selected teaching episodes were analysed using a visual tool developed for this purpose (see Fig 3 later in this paper). The classification of the classroom discourse types followed the method of Viiri and Saari (2006), expanded by the sixth category called student's initiative (Nurkka, 2006). In the classification method the classroom discourse types are divided into six categories: teacher presentation (TP), teacher-guided authoritative discussion (AD), teacher-guided dialogic discussion (DD), peer discussion (PD), student initiative (SI) and other (O).

Students' learning were monitored by using a pre-test (FCI, Halloun, Hake, Mosca & Hestenes, 1995) with four multiple choice questions addressing Newton's third law and by three post-tests. The post-tests were given 1) after teaching the ID and N3 law, 2) at the end of the teaching sequence, and 3) two weeks after the teaching sequence. The post-tests included constructing IDs in various physical situations (altogether eight diagrams in three tests) and four questions on N3 law (two multiple choice questions and one question of force pairs in interactions in test 2 and one multiple choice question framed in a vectorial representation with a written justification in test 3). All the questions were derived from research-based materials. The interaction diagrams constructed by students were categorized according to three quality categories (Table 1).

Table 1. The classification of the quality of IDs constructed by students.

Excellent	Good	Poor
All interacting objects identified.	All interacting objects identified.	At least one interaction is missing or an extra interaction is included.
Interaction line or arrow presented.	Interaction line or arrow presented.	*or* Instead of interactions, forces are identified
Type of interaction (contact or distance) identified *or* a verbal explanation of interactions presented.	Neither type of interaction *nor* verbal expression of the interaction in presented.	*or* Diagram lacks essential features of interaction diagram.

RESULTS

The classroom discourse types the teachers used in episodes of teaching the ID and N3 law varied between the schools and also in teaching content (Fig 2). In each school the classroom discourse type used to teach the ID was predominantly teacher presentation. In school T1 there was more variation in classroom discourse types during this episode than in schools T2 and T3. In the N3 law teaching episodes, schools T1 and T3 used more variation in discourse types than in the ID teaching episode with more dialogic discourse employed.

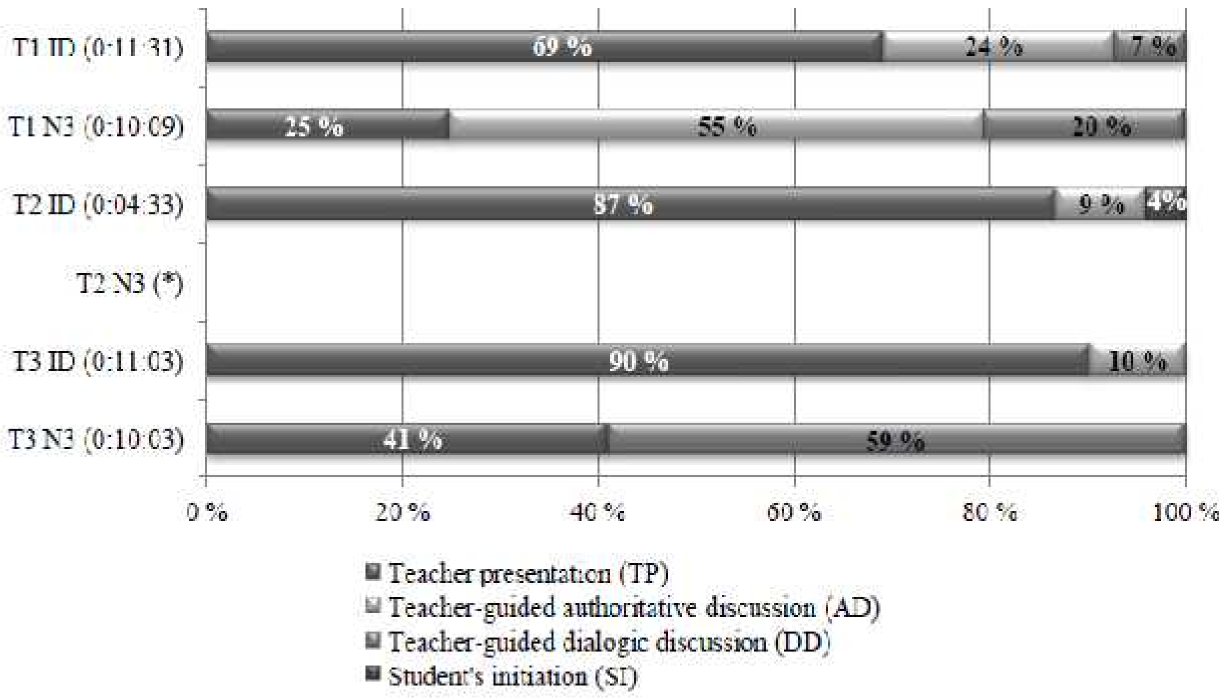

Figure 2. The percentage of classroom discourse types (counted from the duration of episode) during the first teaching episode of ID and N3 law in schools T1, T2 and T3. The total duration of the teaching episode is presented in parentheses. *) The video-recording was not successful.

In school T1 there were more shifts between different discourse types than in the other schools where periods of certain classroom discourse types were longer. As an example of the variation of discourse types, an analysis of the rhythm of the classroom discourse and the purpose of teaching in the school T1 during the episode of teaching of ID is presented (Fig 3). This kind of analysis reveals how the teacher uses different variation of classroom discourse types for different purposes.

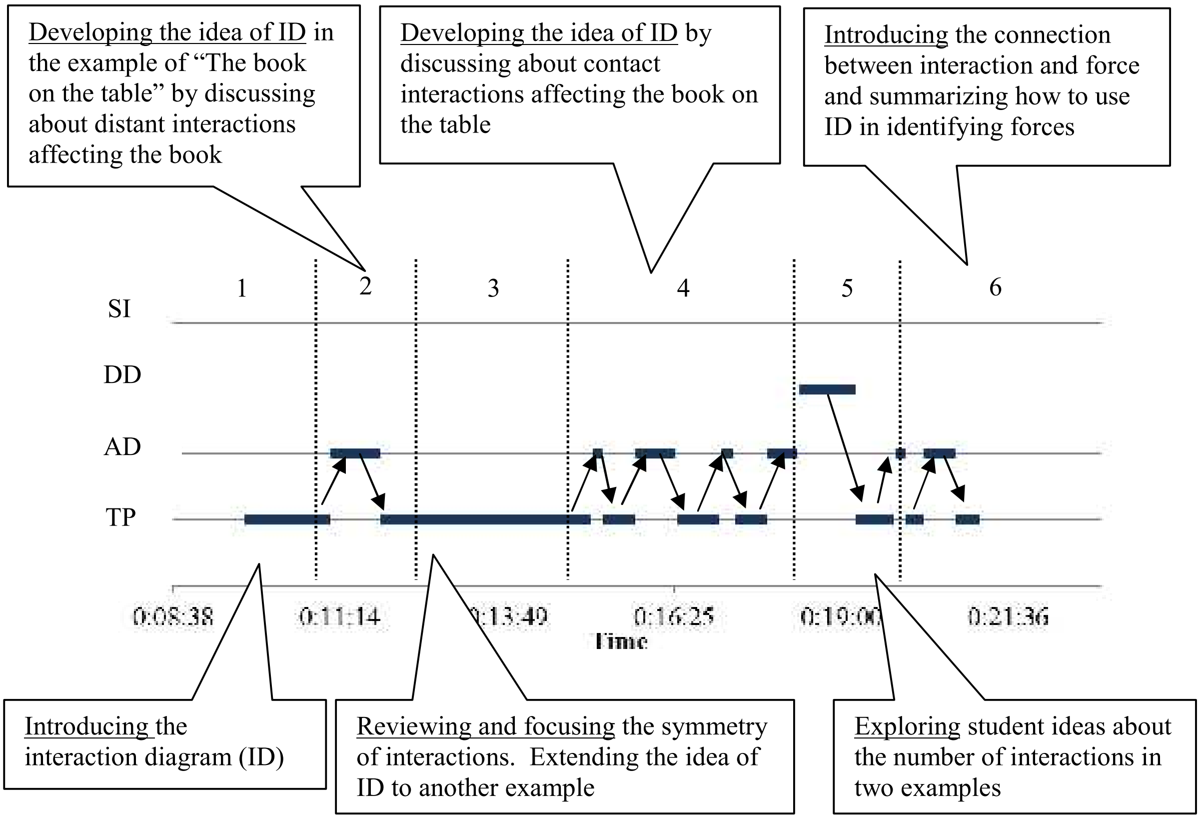

Figure 3. Types of classroom discourse, duration of discourse types, and the content and purpose of topics (1 – 6) in school T1 during the first teaching episode of interaction diagram. TP = teacher presentation, AD = teacher-guided authoritative discussion, DD = teacher-guided dialogic discussion, SI = student's initiation.

The interaction diagrams the students constructed were categorized according to three quality categories (Table 2). In school T1 there were more IDs in category "Excellent" than in schools T2 and T3. Differences between schools T1, T2 and T3 in students' learning of ID were statistically significant as measured by the relative frequencies of different quality categories of IDs ($\chi^2 = 230.3$, df = 4, $p < 0.001$).

Table 2. The distribution of interaction diagrams according to different quality categories (Table 1) in schools T1, T2 and T3. N indicates the total number of IDs included in the percentages below (altogether 8 diagrams in three tests). Students absent from the test or non-answers for the task were not counted.

	Excellent	**Good**	**Poor**	**Non-answers (Number of IDs)**
T1(N = 192)	85%	1%	14%	8
T2 (N = 210)	18%	59%	23%	6
T3 (N = 167)	71%	17%	13%	17

Students' learning results for the N3 law are presented in Table 3. Maximum score for N3 law questions altogether in three post-tests was 4. In counting the learning results only the students who were present in all tests (pre-test and three post-tests) were included. If the student did not answer the question, the answer was interpreted as wrong. There were no significant differences in pre-test results, but in post-tests, the best learning results were in school T1. For the post-test questions the differences were statistically significant between schools T1 and T2 (Mann-Whitney *U*-test: z=2.59, p =.010) and between schools T2 and T3 (z=2.08, p=.038)

Table 3. Learning results of Newton's third law (counted as average percentages of maximum score 4). Standard errors of mean are presented in parentheses.

School	Four pre-FCI N3 questions (%)	Four post-test N3 questions (%)
T1 (N = 23)	28 (5.7)	83 (3.4)
T2 (N = 25)	26 (6.2)	64 (5.6)
T3 (N = 20)	28 (5.7)	80 (4.7)

CONCLUSIONS AND IMPLICATIONS

In teaching N3 law, teachers used classroom discourse types more diversely and they also used more teacher-guided dialogic discussion than teaching interaction diagrams. In teaching IDs teachers mostly used teacher presentation. Interaction diagrams were not very familiar to the transfer teachers before the teaching intervention, whereas N3 law was very familiar to all the teachers. Hence, our results suggest that teacher familiarity with the teaching content may influence the variation of discourse types. The more familiar the teaching content is to the teacher, the more diversely the teacher is able to use different classroom discourse types.

The variation of different discourse types was different in schools T1, T2 and T3. In school T1 the teacher varied the classroom discourse types more often than in other schools and used different discourse types for different purposes, for example, teacher-guided dialogic discussion to explore students' ideas, teacher-guided authoritative discussion to develop the idea of the content, and teacher presentation to introduce the new idea or summarise or focus the key points. In schools T2 and T3 even if the teacher used different types of classroom discourse in teaching N3 law, the periods of certain classroom discourse types were longer and the teachers did not vary the types of classroom discourse clearly according to the purpose of teaching. Even if parts of the video-recording done in school T2 were not successful, other video-data from school T2 indicates that the teacher did not greatly vary classroom discourse types, and in fact used mostly teacher presentation.

Our results provide some evidence that variation of classroom discourse types may support students' learning as reported by Furtak and Shavelson (2009). The best results in the learning of interaction diagram and N3 law were in school T1. In school T1 there was also more variation in classroom discourse types than in the other schools.

In this study we developed a visual tool for the time-based analysis of the classroom discourse. The tool was developed especially to express the relationship between time, variation of classroom discourse types, and purpose of teaching. The visual tool gives the possibility to analyse, reflect upon and modify classroom discourse by taking account of the content and purpose of teaching. Thus we consider the visual tool to be beneficial for teacher education, education researchers, and teachers. In further studies the tool might be developed to be more useful in exploring how the variation of classroom discourse types supports students' conceptual understanding.

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MAKING MEANING OF GRAPHICAL REPRESENTATIONS IN BEGINNERS' PHYSICS LESSONS

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Abstract: Mathematics and physics are characterized through a subtle interplay, not only in science itself but also in physics education. Significant problems arise when students have to connect the different perspectives of these subjects and to use different mathematical and physical representational elements. These abstract objects have to be introduced to the students carefully with aid of verbal explanations in order to clarify this interplay. We describe possible obstacles during this process with an example from beginning physics lessons concerning the steps starting from describing an experiment, its evaluation by verbal circumscription and by graphical and mathematical tools. To obtain a complete picture we first analysed text books. On the basis of the qualitative understanding of pupils and teacher students a questionnaire was developed which highlights possible misunderstandings.

Keywords:

Introduction

Teaching beginners in physics is an exceptional important and responsible task. Introducing pupils to the idealizations of physics and physics models starting from everyday experiences and interpretations requires careful designing of a learning path and choosing an appropriate language. Students do not come ignorant into physics lessons but have knowledge from own observations and from other lessons e.g. in mathematics. Also the teacher has his or her own experiences and is already socialized in physical thinking. Those two different starting points have to be matched. This concerns understanding of fundamental physics concepts as well as simple descriptions and explanations. We will present here an example of possible misunderstandings on the border of mathematics and physics which needs careful attention as critical details might influence the physics course as a whole. Especially tacit assumptions have to be made clear to the students, because between real observations and the description by physical terms and abstract models lies a wide gap whose difficulties often are underestimated, (Böhm et al. 2010). In bridging the gap language serves as a medium for the meanings of symbols, notations etc and hence also plays a central role.

The idealization process in physics is strongly related to the use of physical models as well as of mathematical elements. The interplay of empirical, conceptual and mathematical elements in doing physics is most subtle and shall not be discussed here in detail, (but see e.g. Kuhn (1976), Wigner (1960), Gingras (2001)). The use of mathematical elements on different levels characterizes the physical method and is part of the way of gaining knowledge in physics. Hence, understanding the meaning of mathematical tools for the physical description of the world and their interplay with physical views is one of the most important, but also most difficult steps in physics education. Students have to learn to represent physical relations by mathematical symbols and vice versa. This already starts with the very first experiments where quantities are being compared or measuring values are taken and represented graphically. Students have early experiences in this from mathematics lessons. But there are subtle differences between the teaching in mathematics and physics, caused by their different perspectives. In physics, numbers and the view of graphs have to be interpreted in terms of physics laws which are by themselves only approximations to real processes.

Pupils have to cope with these differences, (Redish, 2005; Pospiech, 2006). The flexible use of representations is a central ability which marks the experts in comparison to novices, (Friege, 2001). Among them the handling of graphical representation takes an eminent role as it is important also for other sciences than physics, (see e.g. Ainsworth (1999), Lachmayer et al. (2007)). Especially the interplay of the representation forms: verbal explanation, diagrams and formula is important for the process of learning and understanding. It contributes to the forming of pupils’ mental models. However, the implicit meaning attributed to verbal descriptions may differ between teachers and their pupils according to their experience. Therefore a common base of understanding has to be developed over time. In order to gain an insight into this process we concentrate on the connection of different mathematical elements with a physical experiment and the mediating language and study the process of making meaning as it is performed by students.

Bridging different representations

The first mathematical elements mostly enter physics lessons in the course of an experiment with taking data, preparing a table of measured values and drawing a suitable diagram. Accordingly, by the term "mathematics in physics" we do not only understand formulas, i.e. the algebraic representation, but also graphical representations. Graphs are an important tool for depicting experimental data and evaluating them whereas formulas are a very condensed way of describing a physical relationship in a precise manner. Generally, they do not have the ambiguity of verbal explanations.

During the learning process a kind of a grammar and vocabulary for the translation process between these representations has to be established. These first steps seem to be simple, but they are the basis for subsequent development of physical thinking and the mastering of methods in physics inquiry. However, beginners have difficulties to grasp the relation between a formula or function and the related graphs. Therefore, formulas and diagrams require verbal explanations which are essential in connecting the different representations. From this point of view the step from phenomenon to the mathematical formulation is gone too fast in the eyes of pupils, (Monk, 1994). Therefore the connection of physical quantities and mathematical tools has to be developed carefully, (Pospiech, 2007). The prerequisite for developing a suitable learning environment is the exact knowledge of possible difficulties pupils encounter. As a first step towards this we conducted a descriptive study with a focus on the interplay of making and interpreting graphs and its verbal description. The central question was: “How is the verbal description set in relation to a graphical representation?”

In beginners' lessons the language has to rely highly on everyday language as the specialized language is not yet at disposal. The everyday language has in general a broader meaning than the specialist language. It lives from associations which can differ between students and teachers, (Pospiech, 2009). Therefore a negotiation process between the parties has to take place. Experienced teachers systematically use key words for this purpose. Often students learn by experience which words to use to denote physical or mathematical relations. Since spontaneous associations together with influences from mathematics lessons are especially important in beginning lessons we choose an example from grade 6 (students aged 11 to 12 years). The research focus lies on whether teacher students and pupils have the same physical or mathematical interpretation of the linguistic terms.

Learning Context

The study on the role of linguistic elements was conducted at an example from introductory thermodynamics. It combines a concrete experiment done by pupils, its verbal description, graphical representation and a mathematical tool, the proportionality or linear function.

The physical context is the thermal behaviour of bodies and the concept of temperature. As it is the beginning of physics instruction the pupils are introduced to the techniques of experimentation. An easy experiment consists in heating a certain amount of water with an immersion heater and observing the increase of temperature. It is an experiment prescribed in the curriculum, by which the pupils learn how to set up and conduct an experiment, make a protocol and so on, mostly from the technical and methodological perspective. This experiment includes several steps: during the experiment the pupils take the time, read the corresponding values of temperature and write them down in a table. After that they are asked to draw the suitable diagram and to interpret it.

In the context of thermal energy the same topic is treated again in grade 8 (13 to 14 years old) with the inclusion of melting and boiling and with the objective of deriving or making plausible the heat equation $Q = c_W \cdot m \cdot \Delta T$.

Therefore we choose this subject from thermodynamics for deeper analysis. The aim is to analyse how the pupils put together different representations and how (future) teachers understand all the terms used in school books, in mathematics lessons and everyday understanding.

METHODS

In a first step we analysed physics text books for schools with respect to their description of the process of heating water and mathematics books concerning definition and use of the term "proportionality".

In the second step students were observed and assessed after doing the experiment "heating water" and its evaluation. From this pilot study a questionnaire for students and teacher students was developed, in order to get a detailed view on possible discrepancies between their use and understanding of language.

Analysis of Schoolbooks

Especially the physics books for grade 6 do not give a precise mathematical description, but circumscribe the process by words. Some of them use the wording: “The temperature increases steadily.” This rises the question, whether pupils connect to the term "steady increase" the correct physical understanding and an adequate graphical representation. In books of grade 8 the corresponding explanation reads:

> “Supplied energy and temperature increase are proportional if no change of state takes place."

> “The heat Q supplied to an object is proportional to the temperature increase ΔT: $Q \sim \Delta T$.”

In the books, diagrams are just given without further comment such that the teacher has to explain their making and interpretation. Mostly the diagrams depict an idealized curve, only in some schoolbooks measuring values are indicated. Measuring values corresponding to the chosen example always lie on a straight line. Only some books refer to measuring errors. So pupils mostly get an idealized image of the relation of real measuring values and their representation.

The mathematics books of grade 6 introduce the concept of “proportionality”, mostly with the meaning: “direct proportionality”, sometimes also the “indirect proportionality”. Therefore the pupils are used to a strict mathematically correct definition of “direct proportionality”, where the corresponding line has to go through the origin of the coordinate system. In grade 8 the most prominent example for a function is the linear function. In contrast to the strict use in mathematics physicists describe arbitrary physical relations between two quantities often with the term “proportional”, as e.g. “Force of gravity is proportional to $1/r^2$”

Exploratory Study and Questionnaire

In the exploratory study the teacher performed in the normal course about thermodynamics the experiment "heating water" with the description in terms of a "steady process". Then the students (n=25, 15 male, 10 female) were asked to describe the results of the experiment (values and graphical representation) by their own words in order to know what they understood by the term “steady process”. These descriptions were evaluated with respect to the used mathematical and physical arguments. A second perspective was introduced by interviewing different people - physicists, becoming teachers, non-physicists - on this topic.

From the answers of both groups we derived possible understandings of the term “steady process” and condensed them into 12 items, e.g. “There are no sudden changes.” or “Something proceeds at constant speed.”, “It is a regular process”. Fitting to these "definitions" we chose 10 graphs, about which we asked pupils and students whether or not they would relate them to a “steady process”. Examples of the graphs included e.g. periodic functions, non-linear graphs and increasing as well as decreasing straight lines. These both aspects - the linguistic as well as the graphical - were combined in a questionnaire.

The questionnaire was given to 63 pupils from two classes (22 male and 41 female pupils) of grade 6 (about age 12) and to 14 physics students (shortly before end of their study). In addition a similar task was given to 63 students of grade 8 (about age 14, 32 male and 31 female). They should assign given graphs to the description: “A physical quantity *M* changes steadily with a physical quantity *L*.”

RESULTS

Exploratory study

The verbal explanations of the students in the pilot study showed that they attributed a “steady increase” only if the measured values lied strictly on a straight line. If there were even small deviations, e.g. by measuring errors, they mostly rejected the steady increase. Furthermore some denied the direct proportionality because the line did not go through the origin of the coordinate system.

The explanations of the students show their attempts of sense-making. There is a tension between the exact description of their own diagrams from the evaluation of the experiment and the ideal images in the schoolbook together with the explanation of the teacher: “*The temperature rises always, but the higher the water is heated up the slower the temperature* *rises. Temperature → rises steadily.”*. Furthermore they try to deal with measuring errors and the perception of what might be correct: “*Temperature should increase steadily, but we make errors and that’s why they do not lie on a straight line. The points in a diagram ought to lie on a straight line.”* Furthermore, the difference between a dependent and an independent variable remains unclear: “*If time increases, also temperature increases. The temperature does not increase steadily, but the time does. Even if time increases steadily the temperature does not increase steadily.”* However, some students seem to adopt the idealization: “*The measuring values lie on a straight line, this means that the temperature increases steadily.”* Some pupils draw a connection to the mathematics lessons: “*The longer the time the higher the temperature. All points should lie on a straight line. This means the temperature rises always equally, but there is no direct proportionality. The temperature increases equally in every minute.”* That this student negates the direct proportionality can be attributed to the fact that in mathematics a direct proportionality always is shown by a straight line through the origin. But not all students transfer this definition equally strict: “*Since the points lie on a line and the time intervals are regular, they are directly proportional to each other and the temperature increases steadily.”*

Concerning the connection of process and graphical representation 16 out of 25 students made an explicit relation between the physical process, the steady temperature increase and its depiction in the graph. Only 11 students mention measuring errors and their influence on the graphical representation.

Results of Questionnaire

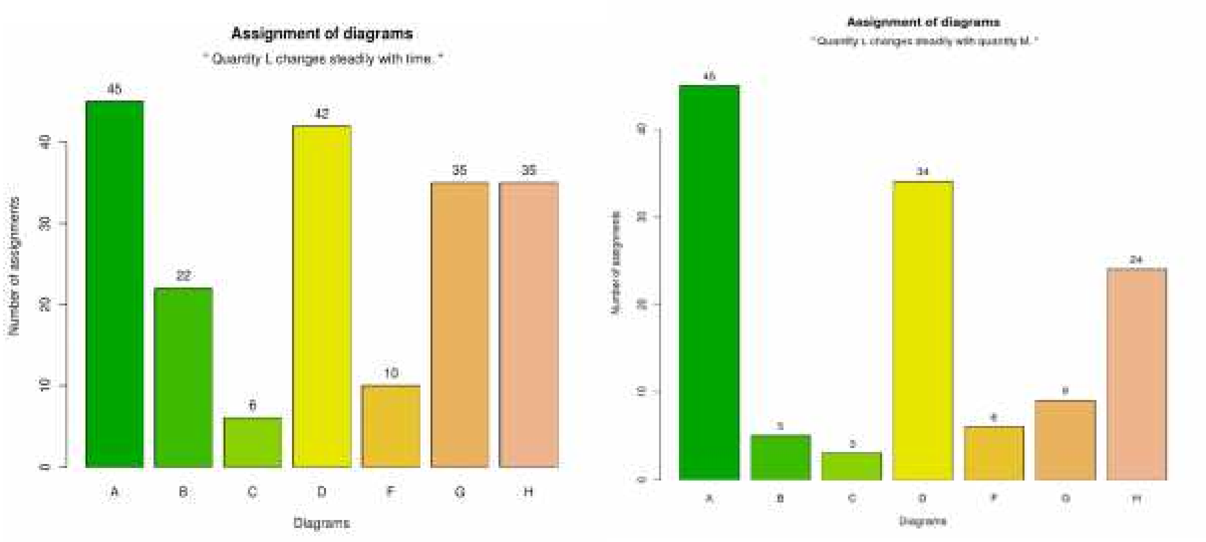
The questionnaire contained 12 alternative expressions for description of “steady process”. One of these had to be excluded because the students (grade 6) did not understand its meaning. Furthermore 10 graphs should be assigned to the sentence: “The quantity changes steadily with time.”.

Most items of the alternative descriptions for "steady process" were answered with a clear rejection or agreement. Especially the statement: “Something happens regularly” as a paraphrase for “steady increase” was agreed to by the students (yes: 71%). Also they agreed to “Something proceeds at constant speed.” (yes: 75%) or “There are no sudden changes” (yes: 76%). Students rejected a steady process if small or slow variations were allowed (no: 75% or 76% respectively). This implies that only smooth lines in diagrams would be identified with a steady process.

Interesting are the differences between students and physics teacher students. For instance the teacher students reject the paraphrase “Something happens regularly” clearly (no: 71%). Concerning the description “Something proceeds at constant speed.” teacher students were undecided, (yes 50%, no: 42%).

Concerning the graphs there is more agreement between the groups of students and teacher students. It is remarkable that increasing straight lines were quite surely accepted by most pupils (yes: 71% resp. 67%) as a depiction of a steady process, but a decreasing line to a lesser extent (yes: 56%)). More precisely, 61% of the students identify a process with constant speed with an increasing straight line, but only 47% with a decreasing straight line. They recognize that both graphs depict similar processes. In this last case there was the biggest difference between the attribution of students and teacher students, all of which connected the decreasing straight line to a steady process. A constant line was accepted by 79% of students as a steady process but only by 56% of the pupils. These differences can easily be explained by the far bigger experiences of students with mathematical functions. In the judgement of the "curved" lines students and teacher students mostly showed quite strong agreement in their classification.

Fig 1: In the diagrams the connection between graphs and the indicated text is given. The left refers to grade 6 the right to grade 8. Straight line graphs are A,D,G,H, where G is the constant function. B,C,F depict non-linear functions.



The question is whether the situation needs an intervention. The results of the questionnaire in grade 8 indicate that the students have reached a narrower understanding of the wording "steady process" and that teachers and pupils have reached a common adequate view (see Figure 1). The experience and negotiation of terms has led - without special intervention - to a quite satisfactory result.

DISCUSSION AND CONCLUSION

Misunderstandings or misinterpretations in beginners physics course can easily appear even at seemingly simple points. Especially interference with views from mathematics lessons where mathematical elements are defined very exactly has to be taken into account in physics lessons. Additional differences occur between the understanding of teacher students and pupils because an experiment, its evaluation or the underlying process are described and explained mainly with words. Those can be quite important for teaching,

This study shows that teachers have to be aware of differences in the attribution of meaning between themselves and their pupils. We see from the results that mathematical elements could - compared to verbal descriptions - secure a more stable accordance between the meanings of pupils and teacher students. Some additional aspects arose: pupils are very strict with respect to small deviances as they happen e.g. with measurement errors. They fall back on ideal standard representations. Therefore in teacher education it is important to show the teachers how to vary the representations, incorporate the possibilities of measurement errors and make clear the idealization process that is necessary for a mathematical treatment.

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MULTIMODAL DISCOURSE IN COLLEGE PHYSICS CLASSROOM. CASE: ELECTRIC FLUX CONCEPT.

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Abstract: A qualitative study based in the analysis of physics explanations in the university classes is presented. The aims is to analyze how the physic lecturer bulding their explanation identifying the multimodal resources and its function in the process scientific meaning building. The topic is Electromagnetism, specifically electric flux. The theoretical frame is structured on the Argumentation Theory by Perelman. The experience is carried out in Engineering School at Carabobo University, Venezuela. The dscourse analysis of three physics lecturers is made from multimodal perspective which takes into account the role of visual representation through action. The results contribute to three aspects: the lecturer resources used when looking for student's adhesion to the explanation, the communicative modes and functions in scientific meaning buldng and the interactive communicative process developed during the physics classes. This work is an advance of a bigger study that proposes to deep on the multimodal action of the lecturer in the meaning building for the development of three-dimensional vision of physics concepts and in general in the thinking of the engineering students, basic competence in the engineering profession.

Keywords: Discourse Analysis, *Rhetoric, Physics Teaching,* Engineering Degree, Science Education.

1. INTRODUCTION

This research is carried out in the Engineering Faculty at Carabobo University in Venezuela The main research aim is to identify rhetorical characteristics in the explanations of physic lecturer in an Engineering faculty through of discourse analysis of lecturers' classes. This aim will be concretise as: a) the description of the scientific meaning building of physics -through of lecturer's teaching analysis in the classroom and from a multimodal rhetoric perspective, that means, considering the convincing potentiality of the multimodal discourse of the lecturer; b) the analyze of how the physics lecturer builds the explanation about the electric flux concept, c) the analysis of the functions the lecturer gives to the multimodal resources he/she uses in his/her classes about electrical flux.

2. THEORETICAL FRAMEWORK

Science explanation analysis

We perceive the educational context from of Vigotsky Socio-cultural theory, where the appropriation of knowledge is caused by social interaction, which can happen in the classroom setting. The teaching learning process is based in the meanings building process lecturers carried out during their classes. We define *the Class* likes a string of speeches developed in a delimited situation in time and place, usually built over several days; in our case, which is guided by an experienced person to a less experienced people with a didactical purpose. Researches carried out about teachers reveal that self reflective practice on their work is a fundamental resource for the lecturers' training in that it involves rethinking the relationships among the content, its teaching and the subsequent learning (Mortimer and Scott, 2003; Ogborn et al, 1996; Kress et al, 2001). Giving to the lecturers an opportunity to be the subjects of their own change and to question their own practice, contrasting it with theoretical elements and reflecting about it, can bring these lecturers to build alternative didactics to respond to new focuses. Also, we perceive the teaching-learning process from the semiotic point of view, because of the scientific concepts cannot be limited to a single language or an only one form of representation. The languages of science involve verbal language, scientific symbolic language, as well as other, as the languages of visual representation, the languages of mathematics, and the languages of experimental operations. All these semiotics resources are rhetorically orchestrated in science classes. The role of the lecturer in this process is very important.

Argumentacion Theory

To build our analytical framework, we base mainly on the argumentation theory of Perelman & Olbrecht-Tyteca (1958/2000) and Perelman (1982). It aims at studying the discursive techniques that allows increasing the adhesion of the audience's minds to the theses that are presented for their acceptance. This theory combines a rhetorical approach with an argumentative one, and which has proved to be a good framework to support the analysis. This theory introduces fundamental elements as: a) premises, formed of the agreements accepted by the audience, which will be the departure point of argumentation, b) theses (concepts, scientific points of view), c) *adaptation of audience (the students)*, in terms of rhetoric the lecturer explanation has to convince students of their theses and this is accomplished first by *preparing the audience* for the discourse, it considers that a discourse is effective when it is focusing on the audience knowledge, to which it directs the persuasion techniques, and considers necessary to find the most appropriate ways to create participation of the audience in the discourse, d) discourse presentation form, it is referred to prosody, verb forms, rhetorical devices and strategies used to achieve *communion* with the audience, e) *the presence*, which is necessary to give to the premises in order to increase its rhetorical value or convincing.

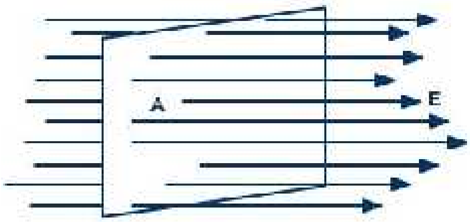
The Presence and Multimodality

The presence is an essential element in the argumentation, based on the selection of concepts and how to present them in order to persuade and convince the student. Before to go to classroom, the teacher have to select, organize and classify content, and to select, consciously or not, a variety of rhetorical means to present the concepts to their students (the audience). Making this selection with a view to persuading the particular audience particular, the lecturers are using the presence from a methodological point of view. Other derivation of the presence notion defined by Perelman is the *presence of second order* introduced by Gross &, Dearin (2003). It refers to accumulative effect of simple presence of elements that produces a greater effect or synergy. We give presence in the explanation when it cause an effect on the student: drawing their attention to the class, reminding the name, equation or mathematical variable, drawing a system, recreating a moving picture, setting in their mind, among others. This type of presence is related with the building of meanings and the multimodality in the classroom. In their research Kress, Jewitt, Ogborn and Tsatsarelis (2001) show us rhetorical functions of objects that mediate the action in the classroom, to give "presence" (make that it becomes more "real) at the conceptual entity, from which students can see new features and qualities that are useful in their conceptual building. Among several presence' resources they are a) showing the imaginary, where an identity is present to the student through the action with the body which acts as a rhetoric sign, and b) the demonstration using physical objects.

In the experimental sciences context, a research line has been undertaken in the University of Barcelona (Fagúndez, 2006; Castells et al, 2007, Konstantinidou et al., 2010). Their results constitute the main antecedents for our investigation. With the obtained results (Rangel & Castells, 2005, 2010) is created a new small research that tries to study the lecturer's action in the classroom from the multimodal perspective when lecturer is scientific meanings building.

Electromagnetism topic: the Electric Flux

In most college physics textbooks (Fishbane, 1993; Sears, 2005; Serway, 2005), we found the use of an initial system to conceptualize the electric flux, consisting of a rectangular surface which is crossed by uniform electric field lines. Electric flux through an elementary area is defined as the scalar product between area vector and electric field (*figure 1*). The meaning of concept electric flux is constructed using both the notion of electric field and electric field lines and a new concept which is defined to treat area of a surface as a vector, where the vector length represents the magnitude of the area and its direction is outward drawn normal to the surface.



$$\phi_E = \iint \vec{E} \cdot d\vec{A}$$

Figure 1. *System used to explain Electric Flux*

3. RATIONALE

The relevance of this study is its contribution in the lecturer training, like a piece of a whole. We consider that the lecturers training has to be done taking into account the knowledge accumulated by lecturers in the self educational context and which is demonstrated with their actuation in the classroom. Our global objective is to improve the physics lecturer action in classroom, by means of starting from awareness about the construction and creation of the explanation in the classroom like scenario and the relationship with their students trying to reach to the development of the scientific knowledge and abilities necessary for an engineer in the students. A way is to characterize the physic teaching in the engineering classroom context trough the analysis of the lecturers' explanation.

4. METHODS

The research is qualitative, based on case studies; it is an analytic and descriptive study, aiming to capture processes and their development. The experience is carried out in Venezuela, in the School of Engineering at the Universidad de Carabobo, resting on the discourse of three Physics lecturers' (Laura, Montse and Pere) teaching the electric flux topic in electromagnetism unit. Data was gathered through direct, non participative, observation, supported by the video recording of classes and researcher's field notes. The information was divided in segments according to the topics, and separated in episodes of one minute each one, called: [D01], [D02],.., [D019]. The final data are presented seeking to be useful for understanding of any science teacher. Through of a transcription process, the table that includes the lecturer speech, drawings on the slate, lecturer movements, and photography shots is built. *Data analysis:* The analysis will be done from the multimodal perspective and specially taking into account the presence in second order in the multimodal action of lecturer. For this study we sought issues such as:

Secuence: a) order: How the lecturer combined the premises, and thesis that she/he goes building?, b) time: How the temporal space is used?, c) the Rhythm: Can we identify lecturer explanations with global functions? Are this ways presents in the three lecturers?

*Multimodal action in the building meaning: a) r*esources used: physical objects, mimic, draws; b) the function of resource: To develope scientific contents or specific abilities.

<u>*Pere's explanation analysis:*</u>
Pere, a young lecturer with Physics degree, he has classes early in the morning. The class has started one and quart hour ago, and there is a lot of noise, because PERE has asked to make four-person teams to deliver some books evaluated exercises. "*Pere: OK, now we let's talk about something else"*. The students' noises continue. He erases slate and then writes [a]Gauss law - Electric flux" - and he goes behind the desk waiting in silence for three minutes. Therefore a little more quiet students Pere began his explanation emphasizing: "*FLUX, is a..."*. He introduces the flux concept [D01], represents the system on the slate [D02], and then continues ([D03] to [D08]) his explanation on the slate describing, comparing and differentiating the system's variables such as surface, area vector, field and field line.

<u>*Montse's explanation analysis:*</u>
Montse, an experienced lecturer with Physics degree, ends her classes just for lunch. The class has started two hours ago, and when Montse says she has a new topic, are heard students saying: "*Nooo!"* She looks a bit tired, and everyone in the classroom needs a break. She will. She gives them encouragement, and introduces the concept with a question, "*what it means for you the word flux*?" [D01]. In D02 to D04 Montse recreates the image of a river and each one of them on holiday in the river banks, "the sound of river "rrrrrrrr",... emphasizing with her body and swinging the arms simulates waves "these are the *waves river"* "*..But the river always gives a sense of calm, of peace* !.." (Emphasized the peace word opening her arms and mouth) *"It is very* nice!" (Pause). The students begin to laugh, relax with the representation of the holidays and the lecturer's humor sense. She combines every day speech with a little black humor without losing sight of the topic, *"How do you measure if a river is more abundant than another?"* In D05, D07, she continues the representation by measuring, this time with two identical "imaginary rings", she dipping one in the Orinoco River and another in the Amazon River. In D08, D09, after she gets students the variable time, she introduces the electrical flux concept, and then she starts electric flux definition. She justifies why the time is not necessary since it is the electrostatic field measure. In D12, D15, Montse describes the system drawn on the board [D10]. She reinforces this explanation with representaton of surface using a folio. She draws on this, littles rectangules representing small areas through which it passes <u>only one</u> electric field line (she emphasizes with her finger). She represents the system on the slate, and then continues her explanation using the folio on slate to describe, compare and differentiates area vector, electric field and electric field line (she emphasizes pointing her hands).

<u>*Laura's explanation analysis:*</u>
Laura, electrical engineer, is one of the oldest Physics Lecturers of engineering Faculty. She has her class in the afternoon. She introduces the electric flux presenting premises unknown for students in [D01]: "*Let us see now the Gauss law and this is the first of Maxwell's equations. Okay? (...) but first let's talk about a quantity which is closely related to the electric field and in particular, to the number of field lines passing through any surface ..."*
In D02 Laura introduces the electric flux: "T*his physical magnitude that is proportional to the number of lines arriving, departing, or coming to the surface, is precisely known electric flux."* She writes on Slate emphasizing the bamed variable and its nomenclature before to draw the system. In D03 she connected electrical flux with magnetic flux which is a new

concept to be studied, she continues drawing the system while she describes it. From D04 to D06, Laura makes a detailed description of area vector, and of its components using the slate to write what she says. She uses a marker to represent the area vector on slate, and she draws a coordinate axis. She leaves the slate and placed in front students asking them: "H*ow is the angle between the vector and the electric field area?.*. It is the same f*or each point on the plane surface."* In D07 to D12, Laura makes a system recreation formed with many elements. She takes a folder as "a surface" and she draws on air a uniform electric field. She uses the walls of sides and her arms to set in the student, the image of the electric field lines crossing classroom. From there, she continues ask them and verify their responses. She writes on the folder a "X" to indicate external face, and uses her arms and finger to represent the area vector and the electric field. She emphasizes with both her body and voices everything she is saying. In D12 to D16 Laura turns to slate and draws explaining this. Again her actuation on the slate is detailed; she draws other positions of same system. She uses the folder to help the students' understanding of drawn it, then she analysises the behavior of electric flux according to variables system such as surface, area vector, field and field line.

5. RESULTS.

This work studied the explanations of three physics lecturer on a same topic using the same system, the findings about the meaning building process are:

The secuence in the Electric Flux explanation and the Rhythm. We identified five phases in the explanation construction as: a) the topic's introduction b) the flux definition, c) the system presentation on slate, formed by the named initial variables and drawing the system on slate, writing mathematical expression, d) spatial representation, using 3D image recreation or making mental images in three dimensions, about the flux concept, e) development of behavior of electric flux supported by mathematical concepts. The figure 2 shows the sequence of the explanation identifying in each phase the multimodal resources, and the most outstanding actions of the lecturer. This secuence shows that although they met the goals of curriculum, each lecturer characterizes a differernt teaching style in which the lecturer organizes, select content, the time spent and resources in each phase, and its combination. We called this the Rhythm of class. These lecturers, each in his/her style use a) the same time to the concept's introduction and to the initial system description, b) the same time to mathematical development, and two of them spent the same time to the recreation of mental images in three dimensions, except Pere, who seems no need spatial representation, may be because of the support of the quality and detail of his drawings.

Multimodal resources used and the Presence. The physics teaching process includes an effort in the multimodal action in the classroom, to create physical systems from imaginary achieving in a high level presence. In this way, many multimodal resources are interacting between them and the students becomes immersed into them being integrated in this imaginary system. The dynamic combination of multimodal resources in the action of lecturers enforces the *presence* of electric flux to students, facilitating the meanings construction. Although, each lecturer had different ways to create the explanation about the same topic even using the same system, we noted an effort along of their explanations for keeping the student attention they were use of their voices, gazes, the inclination of their body, involving the students in the explanation that then will be considered as a whole. The representation modes used were: a) spatial representation, through recreation in scene, b) the use of the body and arms to give presence to the directionality of the electric field and surface vector, c) the spatial representation, using physiycal objects and imaginary objects, d) the representation on the slate, with colorful drawings, using objects physical too.

<table>
<tr><th></th><th>D01</th><th>D02</th><th>D03.. D07</th><th colspan="2">D08.. D12</th><th>D13.. D16</th></tr>
<tr><td rowspan="3">LAURA</td><td colspan="2">introduces topic & electric flux</td><td>draws system</td><td colspan="2">makes an imaginary recreation</td><td>Mathematical development on slate</td></tr>
<tr><td colspan="2">Gazes, voice,</td><td>Slate + Text Detailed +Gazes, voice, drawings</td><td colspan="2">uses a Physical object: FOLDER, Gazes, voice QUESTIONS</td><td>Slate + Drawings Detailed +colors+ folder +physical object + body +.</td></tr>
<tr><td colspan="6">She makes scenario & uses interaction asking and receiving students' feedback.
She uses arms as electric field lines. Uses fingers as Electric field or electric field lines</td></tr>
<tr><td rowspan="3">MONTSE</td><td colspan="3">Topic introduction & Imaginary recreation.</td><td>electric flux</td><td>draws System</td><td>mathematical development on slate</td></tr>
<tr><td colspan="3">Body, arms, hands, voice (context story using familiar places, humor sense , black mood, irony), (onomatopeya, body displacement, movement of arms, hands)</td><td>Slate.</td><td>Slate Use hands/ surface</td><td>Slate + physical object + arms + hands
Use a physical object: (folio) as surface</td></tr>
<tr><td colspan="3">She makes scenario
Uses imaginary objects: two rings
Students: laugh, refuse, respond</td><td colspan="3">Use arms as electric field lines
Use fingers as Electric field or electric field lines</td></tr>
<tr><td rowspan="3">PERE</td><td>electric flux</td><td>Draws system</td><td colspan="2">mathematical development on slate</td><td></td><td></td></tr>
<tr><td>voice, pause</td><td>Slate + colors</td><td colspan="2">Slate + Drawings Detailed +colors+ equations</td><td></td><td></td></tr>
<tr><td colspan="4">He uses pauses (silences).
Uses arms as electric field lines and fingers as Electric field or electric field lines.</td><td></td><td></td></tr>
</table>

Figure 2. Multimodal resources used and explanations' secuence of three physics lecturers.

Preparing audience (the students). The lecturers know their students, its values and hierarchies; this knowledge helps them in the selection of argumentative tools to use, especially the starting points of explanation, to achieve the attention to their verbal explanations. We observed situations in which the students (noisy, tired) were not prepared to pay attention, however the lecturer used resources (sense humor, black mood, onomatopeya, silences, voices) for to reach the engagement necessary with the students and give start the reflexive process of the explanation. The lecturer's discourse is not only built through the transposition of the scientific knowledge to the specific educational context, but of verifying if the audience "receives" the ideas of his/her discourse. Is this continuous search for the agreement (communion with the audience), and the confirmation of the student's attention, what guides the professor's discourse, through feedback by the visual contact, or with the use of repetition and rhetorical question.

***Function of multimodal action in electric flux explanation*.** There were different representation modes of premises and varied functions were identified, some are: a) building the area vector definition, and to reinforce the electrical field line concept, b) differentiating the area vector with the electric field at different points, c) relating the electric flux equation with an adequate surface to solve the integral, d) differencing electric flux cases with different configurations of electric field. We highlighted a common feature in the Lecturers' explanations, the reinforcement of spatial representation and use of many multimodal resources at time.

6. CONCLUSIONS AND IMPLICATIONS

The physic teaching process include an effort in the multimodal action in the classroom, for create physic systems from imaginary, achieving a high level *presence*. In this way, many multimodal resources are interacting between them and the students are immersed into them forming part of the imaginary system. Discourse analysis, allows us to know of lecturer's

Rhythm uses for build meanings and to keep the adhesion of students. This dynamic of teaching gives strength to the *communion* to facilitate the learning. A contribution of this research is the knowledge acquired by the researches through of analysis' process about the teaching process, contrasting it with the own one. The lecturer makes use of all available resources in the classroom to help students to create three-dimensional images of systems that do not exist physically and that it will contribute to the engineer special vision, where the different forms of representation are more important than words. The results of the investigation open us new ways for lecturers' training in order to improve the physics lecturer's praxis, relative to their communicative capabilities for to build a discourse that could be effective for a specific audience.

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THE ROLE OF GRAMMAR IN SHORT VERBALIZATIONS WHILE AUTONOMOUS SCIENCE LEARNING

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Abstract: In contrast to actual research on semantic interpretation or discourse analysis of students' verbalizations in science learning, this contribution is focused on a grammatical perspective. The present paper represents a small part of a broader exploration of motivation and learning of Colombian students working with a German computer-based learning environment. Investigated students (secondary school) worked autonomously during approximately one hour with one unit of the learning environment. 18 students have been video-taped (6 dyads and 2 triads). Their verbalizations were very short and abrupt, for which reason a new linguistic approach has been applied. The aim of this paper is mainly to evidence the method used. Transcripts of verbalized contents of the unit have been coded using a theory-based category system. For the development of the category system, some patterns of the Systemic Functional Grammar (Halliday 2004) have been adapted. Therein grammatical structures of single clauses imply the representation of eventuality (processes by verbal groups, participants by nominal groups and references by circumstantial phrases). Moreover, conceptual networks are given by the cohesion of complex clauses (by means of conjunctions). The reliability of the category system showed on average moderate values. Results evidence the use of single unspecific nouns, material verbs and lacks of cohesion within single clauses and among sentences. This analysis represents a first approach to the diagnosis of conceptual development in its first states, namely the construction of eventuality while abruptly speaking.

Keywords: Autonomous learning, Systemic-Functional-Grammar, Verbalizations

INTRODUCTION

The explorative analysis of the use of a German computer-based learning environment in Colombia has been conducted. The learning environment was adopted within Colombian science classes (8^{th} and 9^{th} grade, 10-11 years old students) in four different schools. The investigation was divided in three parts: (1) external conditions of the schools, (2) motivation of students in terms of self-determination while working with the computer-based units and (3) learning processes. In this contribution, only selected results related to (3) learning processes and the corresponding empirical category-based analysis of video-taped sessions will be presented.

Video-taped students' groups should work approximately one hour on the contents, using digital and real material concerning one unit of the learning environment about the "red eyes'-phenomenon" (on photos made with flash in dark surroundings). The learning aim was to combine light properties with those of the human eye. Students had to deal with nine exercises within the unit.

Students talked abruptly about the themes of the recorded unit. Most of them didn't express themselves using completed utterances. The following examples of the verbalizations concerning the reasons for the "red eyes'-phenomenon" (1^{st} exercise of the unit) present difficulties for a content analysis (vs. hermeneutical analysis)[1]:

- 1^{st} Example: "I think… I don't know… because the flash is more… is more oriented to the eyes, therefore… what do you think?"

[1] Examples in Spanisch. *1^{st} Example*: "Yo creo… no sé… porque el flash es más... está más orientado a los ojos... por eso... ¿Usted qué piensa?". *2^{nd} Example*: "La luz rebota". *3^{rd} Example*: "Luz".

- 2nd Example: “The light is rebounded”.

- 3rd Example: “Light”.

Students expressed themselves autonomously. They talked some minutes about the task and then wrote their conclusions into a predetermined field for answers of each exercise. They were not asked to think aloud. They should explain their findings to their teachers, but in most of the cases they did not do it. Subsequently, some difficulties emerged for the data analyses and corresponding empirical approaches for a scientific investigation of such verbalizations couldn’t be carried out: (1) Most of the utterances were not *argumentations* (e. g. Kelly et al. 1998; Toulmin 2003; Jiménez-Aleixandre & Erduran 2008; von Aufschnaiter et al. 2008), but verbalizations of perceptions or incomplete statements. (2) In some of the cases the concepts expressed were difficult to interpret (e.g., 3rd example), so that *conceptual change* cannot be determined (e. g. Vosniadou 2007; Treagust & Duit 2008; Tiberghien et al. 2009). Moreover students did not show a need of conceptual acquirement.(3) They had not the quality of *metaphors* (e.g. Tobin & Tippins 1996; Thomas & McRobbie 1999; Geelan et al. 2006; Tobin 2006). Most of expressions are just uncompleted ideas. (4) A scientific process meaning a systematic process of *problem solving* couldn’t be directly observed (e.g., Bransford & Stein 1997; Lederman 2007). (5) The verbal *interactions* among students (von Aufschnaiter 1999; Kelly 2007) were frequently incomplete. A discourse couldn’t be detected in most of the cases. (6) Most of *learning processes* appeared as declarative (mental) vs. motor (actions) (Welzel & Roth 1998; von Aufschnaiter & von Aufschnaiter 2003). Some of these declarative processes couldn’t be interpreted in terms of complexity (as shown).

Because of these caveats, it has been decided to investigate linguistics within the verbalizations in a first step of the study. The role of language in science education has already been established (e.g. Carlsen 2007) especially based on Vygotskij’s theoretical appreciations (Vygotskij 1978). But most of empirical approaches are concentrated on interactional, semantic and conceptual meaning of verbalizations. In contrast, the present study of basic grammar properties of verbalizations contributes to the representation of things and events observed or thoughts. This issue has not yet been considered in science educational studies.

The investigation of grammatical content of verbalizations would concern the study of “static” states, that is, “learning states”. The development of those learning states should yield learning processes. This step of linguistic grammatical analysis of learning states is exclusively going to be presented in this contribution. Other steps of the investigation (contextual interactions and interpretation of semantic meanings) have been analyzed, but are going to be presented in future publications. For the present analysis the Systemic Functional Grammar has been used (Halliday 2004).

RATIONALE

Halliday and Matthiessen are the most important exponents of the development of a complex taxonomical architecture of language named Systemic Functional Grammar, SFG (e.g. Halliday 2004; Matthiessen et al. 2009). Herein the functionality of grammar (how language is used) and its growth over generations shaping the communication system are the fundamental properties. In the SFG, the representation of experience through language has been defined and categorized with reference to the grammatical functions of the constituents of verbalizations. In this contribution merely few aspects of the SFG have been accounted for the empirical analysis of learning states. The most important issue is how simple clauses (i. e. the students’ verbalizations) can be categorized for a quantitative content analysis.

Halliday and Matthiessen have defined five dimensions of language in terms of functions of phonemes, morphemes and clauses (which are “structure, system, stratification, instantiation and metafunction”) (Halliday 2004, p. 24). In the present contribution the stratum of “lexicogrammar” (“meaning transformed into wording”) (ibid.) represents the key for quantitative analysis. Furthermore the present approach is concentrated on the “ideational” metafunction (language as “construction of human experience”) (Halliday 2004, p. 29).

In the framework of the SFG, a simple clause with the quality of representation (of human experience) can be defragmented in processes (verbal groups), participants (nominal groups) and circumstances (adverbial and prepositional groups). The following paragraphs shortly explain the categories of processes, participants and circumstances used and adapted for the grammatical study.

- There are six types of representational *processes* ("material, existential, relational, verbal, mental and behavioural") (Halliday 2004, p. 172, ff.). Only material, existential and relational processes have been selected for the present analysis (processes of happening, creating, changing, doing, acting, existing, attributing or identifying). Verbal, mental and behavioural processes (meaning, thinking, feeling, seeing, and being conscious) reinforce in some extent the opinion or intention of the verbalization but don't account for additional information concerning the experiential content of the verbalization.
- *Nominal groups* have been categorized within representational clauses in the SFG as "deictic" (determination of a thing or event), "ordering" (potentiality of the elements of the group) and "qualifier" (additional information about the thing or event) (Halliday 2004, p. 312, ff.).
- Enhancing *circumstantial groups* (groups that answer the questions what?, where?, how?, why? or under what conditions?) are classified into "extent and location" (construction of the process in time and space), "manner" (how the process is actualized), "cause" (why the process is actualized), and "contingency" (conditions for the actualization) (Halliday 2004, p. 259, ff.).

Complex clauses are linked by "logogenesis" ("creation of meaning in the course of the unfolding of text") (Halliday 2004, p. 530, ff.). Logogenesis actually occurs in all strata (not only in the lexicogrammar) and all metafunctions (not only the ideational). In the case of complex sentences in which the subordinate clauses enhance the meaning of the main clause, the *conjunctions* give information about the relation of a clause to the previous one (Halliday 2004, p. 540, ff.). The system of conjunctions is similar to the enhancing circumstantial group seen before (spatio-temporal, matter, manner, causal-conditional).

Verbal groups as processes, nominal groups as participants, circumstantial groups as attendants and conjunctions as logogenetic nexuses for complex construction of meaning are the basic components of clauses which grammatically represent the expressed actuality. These components have been quantitative analyzed in the empirical study.

RESEARCH DESIGN AND METHOD

An explorative investigation has been accomplished. The German computer-based learning environment was implemented in four schools in Colombia. Eight classes took part in the investigation (one 8^{th}, five 9^{th} and two 10^{th} grade classes). 18 students (4 girls', 1 boys' and 1 mixed dyads; 1 boys', 1 girls' triad) have been videotaped while interacting with one unit of the learning environment during approximately one hour (total recorded time: 8h19min14sec). The unit concerns the "red-eyes'-phenomenon" and the parts and functions of the human eye. It contains nine exercises: (1) Previous knowledge; (2) Internet inquiry; (3) Use of a model of the eye; (4) Parts of the eye; (5) Test about the parts of the eye; (6) Similarities to animals' eyes; (7) Functions of the parts; (8) Test about the functions of the eye; (9) Reflexion about the red-eyes' phenomenon.

Deductive content analysis has been conducted (Mayring 1983, 1987). The recorded verbalizations of students related to the content of the learning environment have been transcribed for their analysis (time of analyzed verbalizations: 40min23sec). The analysis of the Spanish transcripts has been done by one researcher. The grammatical categories introduced in the rationale have been slightly adapted to the situation for quantitative analysis (Table 1). The following category system has been used:

Table 1: Categories and Subcategories adopted for the analysis of single and complex clauses adapted from SFG.

Single clause			Complex clause
Verbal (Process)	*Nominal (Participants)*	*Circumstances (Adverbial, prep. Phrase)*	*Conjunction's type*
1. Existential	1. Determination	1. Localizing	1. Reference (spatial-local)
2. Material	2. Property	2. Manner	2. Contingency
3. Relational	3. Quality	3. Contingency and cause	3. Manner
			4. Causality

The components that appear in each verbalization (verbs, nouns, adverbial or prepositional phrases and conjunctions in complex clauses) have been recognized using a category-based analysis. Total amount of categorized components have been calculated as a function of exercises and of groups. In order to represent a manageable overview of the results, the total amount of categorized components has been multiplied by the corresponding time-rates: (Total recorded time) / (Time of corresponding verbalization).

Before the last analysis was implemented, a reliability test of the category system has been carried out. For it, it was necessary to use German verbalizations (so that they could be coded by German researchers). Therefore, previous recordings of German students' groups working with the learning environment have been used. Transcripts of verbalizations of six students (2 girls' and 1 boys' dyads) have been analyzed by four researchers. The total transcribed time was 10min42sec. Fleiss' intercorrelation coefficients, significances and effect sizes have been calculated for each subcategory. In summary, it can be concluded that agreement by coding (Fleiss' kappa over 0.5) presented a high level by some frequent subcategories: Material (within Verbal), Determination (within Nominal), Contingency and cause (within Circumstances) and Contingency (Conjunctions' type). These subcategories showed high statistical significances ($p < 0.001$) and effect sizes (over 0.4). Other subcategories were coded less frequently and got moderate values for Fleiss' kappa and effect sizes. Only one subcategory (Quality within Nominal) showed no significant values. After coding, troubles of researches by coding have been discussed. As conclusion of this reliability test, the definitions of some subcategories have been more concretized.

After this process a final reliability test has been conducted. Herein N=55 verbalizations of the Colombian sample have been coded by two Spanish speaking researchers. Cohen's κ show high significant results for all four main categories (Verbal: .692**, Nominal: .726**, Circumstances: .576**, Conjunctions' type: .451**; (**) denotes high significance). Despite the good agreement of the test, it has to be reported a very high coincidence (more frequently than random) of intercoding. Assumedly the sample used for this test of intercoder-reliability contained several patterns, which could be easily recognized by both researchers. Further research is therefore needed in order to validate this first test. Moreover, the future samples analyzed with the present method should include more manifold verbalizations, e. g. by means of Think Aloud protocols (Ericsson & Simon 1987).

RESULTS

The following diagram (Fig. 1) shows the results of coded verbalizations multiplied by time-ratio over the categories and subcategories of the system used. The bars represent the nine different exercises of the unit. The purpose of the diagram is to show a comparison of the rationalized codes in dependence of the subcategories for each exercise.

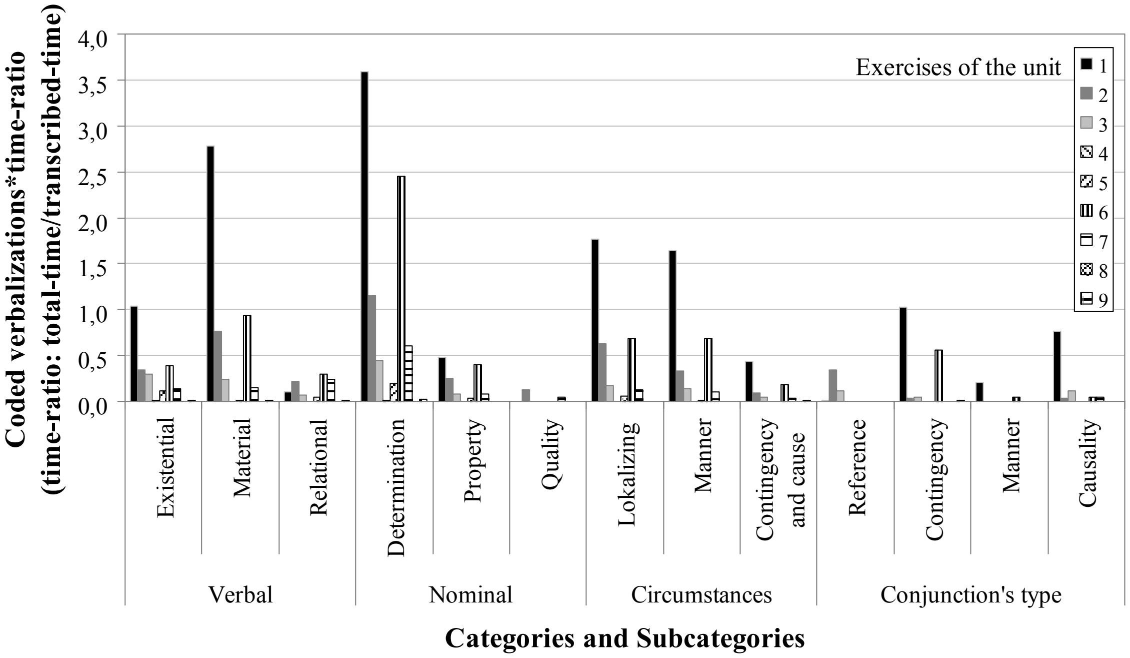

Fig. 1: Time-normalized coded verbalizations over the presented categories and subcategories. All results are presented in terms of the exercises (legend).

The diagram shows that material verbal groups (e.g. verbs expressing, what occurs) and determinative nominal groups (e.g., single nouns) achieved the highest levels. Moreover students verbalized more often during exercises concerning prior assumptions (1st, about red-eyes'-phenomenon and 6th, about animals' eyes). Within the category "Circumstances" localizing and manner adverbs (e.g. describing where and how something occurs) more frequently used. It also has to be highlighted that complex clauses within the category Conjunction's type have been detected in less verbalizations. When students constructed complex clauses they used contingency (e.g., "if… then") or causality (e.g., "because…"). They almost didn't speak by means of references (e.g., "where…", "when…") or analogies (e.g., "as…").

CONCLUSIONS AND IMPLICATIONS

A lack for analyzing short verbalizations of students in science education research has been stressed in the present paper. A grammatical approach for this task has been illustrated. The Systemic Functional Grammar (HALLIDAY 2004) has been used for the development of a category system for quantitative analysis of short verbalizations. Therein the lexicogrammatical content of words expressed (verbal and nominal groups, circumstances' phrases and conjunctions linking complex clauses) could be examined. This new method showed an overall moderate reliability.

It can be interpreted from the results that students mostly spoke asserting common nouns and describing happenings by means of verbs. The expression of coherence between simple events (subcategory Relational in Verbal groups) was rarely coded. Complex cohesion of events using conjunctions was insufficient, too. Analogies (Manner in Conjunction's type) were used very seldom. These lacks of coherence and cohesion in the verbalizations can be taken as deficit of mental networking. Instead of that, most of verbalizations consist of expressions of perception and static states in the actuality (by means of material verbs and determinative nominal groups).

This analysis has shown how basic grammatical issues can be used for the identification of initial states of thinking based on the linguistic study of verbalizations. In fact, syntactic and lexicogrammatic processes are firstly recognized by the brain (FRIEDERICI & ALTER 2004; BARSALOU et al. 2008; BORNKESSEL-SCHLESEWSKY et al. in press). Therefore basic grammatical (syntactic) patterns could also be considered previous to conceptual study for educational purposes.

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TEACHERS' CHANGE OF CONCEPTIONS ON ARGUMENTATION AND ITS TEACHING

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Abstract: this study shows the changes in the conceptions of the epistemological, conceptual, educational and structural aspects of five primary teachers. Those said changes occurred before and after those teachers took part of a process of critical discussion of their teaching practices on argumentation in Science class. In order to identify the changes in the four aspects, a content analysis to a questionnaire applied at the beginning and at the end of the process was done. The results showed a significant change in the components: epistemological, conceptual and educational, and not that much in the structural one. Apart from that they ratified the importance of offering spaces of participation for the teachers to discuss, evaluate and propose mechanisms to improve their practices in the classroom.

Keywords: Argumentation, teachers' conceptions, dialogic education, argumentative structure.

INTRODUCTION

Background and rationale

Many linguists and epistemologists have recognized the central role of argumentation not only in the construction of science, -since it allows substantive relations between models and evidences-, but also in the educative field because the argument is a form of discourse that needs to be appropriate for children and explicitly taught through proper instruction, structured tasks, modeling (Von Aufschnaiter, Erduran, Osborne & Simon, 2008; Erduran, Simon & Osborne, 2006), and argumentative experiences (Aleixandre & Díaz, 2003). Additionally, researches done in the field of the teaching of argumentation in Science Class, show the need, not only to teach how to do it, but also to involve teachers so that they can be conscious of their conceptions about argumentation (Driver, Newton & Osborne, 1998; Simon, Erduran & Osborne, 2006; García-Mila & Andersen, 2008).

Two more reasons that support the development of this study are: First, that with this research, although we will focus only on argumentation in Science class, we want to contribute to the development of scientific thinking in children which is one of the principal goals in the Colombian Educative Policy. Second, we believe that with this work, we can give extra opportunities to improve teacher practices, because elementary school teachers do not have any training in argumentative processes. That is why, teachers do not emphasize on the importance of dialogical processes in their classroom.

From this perspective, this research has as general objective, to identify changes in the epistemological, conceptual, educational and structural aspects of the arguments elaborated by the teachers who take part in a process of critical reflection, on the teaching of argumentation in Science class.

Research context

This investigation was developed in a state institution called Fe y Alegría in Manizales, Colombia. This institution has approximately 2250 students and it is located in a marginal zone of the city. There, we worked with five primary teachers, in 4th and 5th grades. Four teachers are graduated from a special high school where their principal emphasis is Pedagogy; one of them is graduated of Academic High School.

METHODOLOGY

To achieve the specific goal that was presented before, the following activities were implemented:

- Initial and final questionnaire. We applied the same questionnaire at the beginning and at the end of the process (seven months after starting the critical process). The questionnaire had seven opened questions,
- Classes' recordings. We recorded the first class before starting the critical discussion process, because it was important to know how to start with the teachers in this process.
- Meetings. There were some critical discussions about the role of argumentation as a tool to teach in class of Science. Besides, the discussions were also related to the structure and function of the argumentative components. In order to do it, teachers had three meetings. Each one lasted five hours.
- Design and application of activities. Each teacher designed and applied the first activity for the teaching of argumentation in her/his own class (the activities were video-recorded).
- Observation and analysis of the recorded classes. The participants observed the videos and then, discussed their viewpoints in groups. They also gave some proposals to change or overcome their weaknesses.
- Design and application of activities. Again, each teacher designed and applied the second activity for the teaching of argumentation in class of science (activities were video-recorded).
- Analysis of the video recordings and application of the final questionnaire seven months after the process have started.
- Interview. After each class we conducted an interview with teachers for them to reflect on their performance.

Data analysis

To characterize and identify the changes in the conceptions of teachers, a content analysis to the questionnaire applied at the beginning and at the end of the process was done. The transcription and codification of the information was done with the help of the Atlas-ti software. To do the content analysis and subsequent quantification of the codes constructed, we applied the formula: % Code = code number of citations X 100 / total citations, which allowed the construction of some frequency tables.

RESULTS AND DISCUSSION

The table shown below shows the results of the four components discussed in the initial and final questionnaire:

Component	Category	Subcategory	Results questionnaires	
			Initial (100%)	Final (100%)
Epistemological	Relationship argumentation – science	Yes	69,23	92,31
		No	30,77	7,69
Conceptual	Recognition of argumentation as/a	Informative Process	80	0
		Dialogic Process	20	42,9
		Learning tool	0	57,1
Educational	Relationship teaching-argumentation	Yes	100	100
	Criteria taken into account in their teaching: Student (S), Teacher (T), Knowledge (K), Context (C)	S	22,22	0
		S-T	44,44	27,27
		T-K	33,33	O
		S-T-K	0	45,45
		S-T-K-C	0	27,27
	Classroom management - Type of activities	Individuals	50	10
		Groupal	50	90
Structural	Level of arguments	1	33,11	9,37
		2	41,67	53,13
		3	13,9	31,25
		4	8,33	6,25
		5	0	0

“Table 1. Results obtained with the initial and final questionnaire”

Next, a short discussion of the findings obtained in the first three aspects: Epistemological, Conceptual and Educational, is going to be introduced. Some examples of the teachers' answers will be included to support our discourse.

1. **Epistemological aspect:** The situation to investigate this aspect was:

   There are two general concepts of science:

   - Science is a cumulus of absolute and objective knowledge which is the result of a linear process that comes from the observation and experimentation about the real world to scientific theories.
   - Science is the result of a negotiation process among the members of scientific communities where models and theories constructed as a representation of the world are presented, discussed and validated.

> Which one of the two previous concepts, do you think is the most suitable for the teaching and learning processes in the science classroom?. Support your answer.

One of the answers given by one of the teachers in the first application of the questionnaire was:

> Teacher: The two processes are important for the construction of science, given the fact that in the science teaching process there should be experimentation, observation, comparison, analysis, comprehension and dialogue with other people who are performing the same experiment and investigation in order to arrive to some conclusions.

As observed in the teacher's answer, for her, both processes are important in the construction of scientific knowledge. She justified her answer by affirming that, to arrive to a conclusion, you need some spaces to experiment, observe, understand, and interact with the scientific community. She added that the community –or "people" in her own words- have to be involved in the experiment or research experience. However, this is not always true in the process of construction of science.

In the second application, one of the answers was:

> Teacher: Yes, they are. (This teacher here referred to the two processes introduced in the question. She said both of them are important). They are important because the person who belongs to the scientific community, needs to observe and experience first and then, by doing so, that person would be able to introduce, discuss and validate his/her ideas in a group.

In the answer of that teacher, she stated not only the importance of both processes, but she also recognized the importance of debate and group work to knowledge validation. That relationship she mentioned is in agreement with some authors' ideas (Von Aufschnaiter, Erduran, Osborne & Simon, 2008). They claim that arguments that have been previously discussed, contrasted and validated in the scientific community are useful tools to the promotion and development of knowledge. Thus, the answer of that teacher shares the current theories on argumentation nowadays. According to those tendencies, argumentation is seen as a supporting mechanism to keep a qualified scientific knowledge and also as a scenario that promotes mobility from an interpsychological to an intrapsychological perspective. From that point of view then, argumentation is taken as a dialogic activity (Erduran, Simon & Osborne, 2004).

2. **Conceptual aspect.** The question exposed was:

If you were invited as a lecturer to an event on argumentation in the science classroom, what kind of explanation would you give of what it is supposed to be argumentation in the science classroom?

In the initial questionnaire, 80% of the texts produced by the teachers conceived argumentation as a process whose attempt is informative (perspective that tends to a structuralistic view of argumentation):

> Teacher: Argumentation is to provide a set of reasons or evidence to support a conclusion or some assumptions. By means of them, people try to decide what opinions are better than the others.

Only one of the answers (20%) assumed a concept of argumentation as a dialogic process, approaching to a functional perspective of argumentation, for example:

> Teacher: Argumentation is a clear and accurate concept of the issue which will deal, argumentation is to convince others to reach a conclusion.

In the final questionnaire, we found texts that demonstrated a dialogic perspective of argumentation, that is to say, they conceived argumentation as a social activity that requires the generation of a suitable atmosphere for its development. An example of this approach is found in the following extract:

> Teacher: Argumentation in science classes is to express what each one understands from his own daily life, refuting concepts if needed. It also means to be able to explain why things happen, and by doing so, to create socialization settings to generate an appropriate atmosphere where everybody can discuss.

Similarly, identified in the final questionnaire, the emergence of a new conception of argumentation as a learning tool (57.1% of the answers show this trend), that evaluates knowledge, for example:

> Teacher: Argumentation in science is a tool for evaluating knowledge. It is also a social process that is affected by ideas, prejudices and instances; it potentiates changes in the conceptions of individuals, leading them to rethink their knowledge about their surroundings.

3. **Educational Aspect.** Two question were presented to teachers:

- State two things science teacher should take into account in order to teach argumentation to his pupils?
- If one of your main objectives in your classes is to foster the argumentation process in your students, write two activities which might help. Support your choice for each of the activities.

After the first application of the questionnaire, teachers centered their criteria towards Students (22, 22%), the relation between S-T (44, 44%) and T-K (33,33%). An illustration of the first aspect is presented below:

> Teacher: The children's intellectual development and the development of their comprehension and analytic skills.

This answer shows the teacher's tendency towards students. This sentence implies that according to that teacher, learning depends on the development of the individual. This way of thinking contradicts the Vigotsky's sociocultural theory. According to Vigotsky, learning is a process and this process implies social interaction. Additionally, that interaction contributes to the person development. Therefore, learning is based on dialogic processes.

One of the things that emerged from the application of the questionnaire is the relationship student-teacher-knowledge and context:

> Teacher: We should create a class with appropriate conditions, with the teacher's help. We should help students to identify data and affirmations, doing group work using guided-questions; students should learn to listen, speak and justify their assumptions; They should be able to choose the best options.

An outstanding element in the previous answer has to do with the teacher's role. It is understood here as a support or help to the construction of a class. According to this view, power relations in spite of being part of the class, they would not be so notorious because one of the characteristics of interaction are the symmetric relations between student-teacher (systemic model, Contreras, 1990, cited in Levin, Ramos & Adúriz-Bravo, 2008). Also, because in power relations, they (students and teachers) are co-participants in the creation of such interaction scenario (Wolfe & Alexander, 2008).

The second element of the answer refers to group work as a key element to develop argumentation in Science class (Osborne, Erduran & Simon, 204b). The third element refers to choose from different options. Regarding that, it is important to mention that one of the basic processes for the evolution of science is the choice of an appropriate model theory. This selection focuses on the model that better explains the phenomena (Giere, 1999). In sum, in the answer there was a concrete intentionality: "search for the best option". That intentionality is similar to the process followed in the construction of knowledge.

To refer to the activities, in the first application of the questionnaire, teachers talked about two kinds of activities: Individual (50%) and group activities (50%). Next, we are going to give an example of the first type of activities. With these activities we could observe learners as receptors of external stimuli and information. They do not have previous knowledge about the phenomena or theories introduced in class.

> Teacher: Do some experiments with plants or living organisms. It is good for children to observe what happen at the different stages in the process.

In the second application of questionnaire, we could see changes in the kind of activities. An example is provided below:

> Teacher: the most important is that the group can work with a coordinator or representative who collects concepts and writes them down. Participation and interaction are essential.

As noticed, according to that teacher, it is good to work in small groups, there, students could share their ideas and later, socialize them in class. This is interesting especially because it promotes the in pupils their abilities to synthesize, listen, value ideas and get into agreement.

CONCLUSIONS AND IMPLICATIONS

The results at the end of the process show significant changes in three components:

- **Epistemological**: in the final questionnaire the teachers recognized science is affected by communicative processes, teamwork and several debates with the scientific community, to validate results.
- **Conceptual**: the most significant change here was the emerging of a new conception, argumentation in class of science as tool of learning. This conception is related to the one exposed by some authors who see in argumentation a possibility to support intentions addressed to solving some problems of learning and understanding better these processes in the classroom. (Jiménez-Aleixandre & Erduran, 2008)
- **Didactic**: a significant finding in our research refers to the criteria for teaching argumentation. This criteria is strongly related to the elements student-teacher-knowledge and student-teacher-knowledge-context. Taking those elements into consideration mean a functional perspective of argumentation, where interaction is

important but not only the one between subjects, but also where it takes place (the context) and which is the knowledge involved in this communicative process.

- For the fourth component, **Structural**, although there is an increase of texts constructed by teachers, characterized by the presence of data, denial, and some justification (Level 3, Erduran, Simon & Osborne, 2004), but we don´t see important changes in the other levels, then we consider it is necessary to continue creating environments where teachers can, critically, propose mechanisms for the improvement and development of more complex argumentative texts.

From these findings we confirmed how important the teaching of argumentation in science class is. Involving teachers in processes of critical discussion, assessment and leading them to be aware of their own views, is the first step towards the improvement of their practices in science classroom.

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RELATIONS BETWEEN THE ARGUMENTS SET OUT IN SCIENTIFIC PAPERS AND ARGUMENTS PRODUCED BY STUDENTS

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Abstract: The work presented here suggests that school culture regulates the way students access objects of scientific culture. As object of analysis, were taken two texts of scientists and ten texts produced by students on the same topic, the notion that the DNA molecule is the carrier of hereditary information. Toulmin's argument pattern (1958/2006) and the linguistic marks of Koch (2000) were used to identify elements of the arguments and their relations. The analysis of the texts showed that students make use of substantive arguments, while scientists construct their texts by means of analytical arguments. The use of different tenses of speech reveals the transformation of a functional biology into a historical narrative. The selection and use of lexical qualifiers made visible the shift from alethic to epistemic modalities, which presented different uses in scientific texts and in those constructed by students. It was possible to argue that the route taken by students to access scientific truths or to construct views of science involves different stages and processes of those covered by the scientists. If, on the one hand, it is not sufficient for the purpose of science education to provide the understanding of results and conclusions produced in the scientific sphere, on the other, not all the rules are accessible to students. Thus, science education must be seen as a process of constructing an idiosyncratic view of science that involves the understanding of its concepts and language, not by means of adopting this new culture, but to be able to interact with it.

Keywords: school culture, scientific culture, science education, biology education, argumentation

INTRODUCTION

Interest in the study of scientific argumentation in the classroom has substantially increased over the last decade. Moreover, studies in this area have become internationalized, as witnessed by the increase in the number of articles authored by researchers from various countries in scientific magazines published in English (LEE et al, 2009). The analysis of the argumentative discourse is considered one of the ways to access the elaborations of students on knowledge-related issues. These studies focus on the argumentation ability of the student and on the strategies used by teachers to foster this ability. However, only a few studies to date have addressed the means whereby scientists construct arguments in publications such as reports and academic articles. Still, we believe that the understanding of the properties of the scientific argument as used in scientific publications can contribute to research in science education, since the rational criteria underlying the production of scientific knowledge can be uncovered and, thereafter, best embodied in the development of the natural sciences curricula in schools.

This study is developed within this context, being aimed at investigating the nature of the scientific language in the scientific and the school contexts. We believe that by doing so it will be possible to ultimately assess of the nature of the knowledge retained by students during the process of learning.

METHODOLOGY

The analysis of the scientific arguments put forth in a scientific article is based on two original scientific articles (HERSHEY, CHASE, 1952; AVERY et al, 1944), which study the DNA as the carrier of hereditary information. Similarly, we analyze ten essays written by students in their last year of secondary school on the same subject. We used Toulmin's argument pattern (1958/2006) and the linguistic marks of Koch (2000) to identify elements of the arguments and their relations.

According to Toulmin (1958/2006), the step which authorizes the establishment of a *claim* (C) from any *data* (D) is called a *warrant* (W). *Warrant* is the information from which the argument is constructed, and which legitimizes a claim in the field of interest. However, the *warrant* is valid only under certain facts, observations, experiments, knowledge and laws by which they were established. It must have a *backing* (B) to make its formulation acceptable. It must also possess *modal qualifiers* (Q) – terms like *certainly, presumably, probably, necessarily* – that lend strength to the conclusions; and must have counter-arguments or *rebuttal* (R). When the conclusion is a simple statement of *data* and *warrant*, and does not present any new information, the argument is considered *analytic*. Conversely, when information between *data* and *warrant* are relevant, the argument is referred to as *substantive*.

The *linguistic marks* of Koch (2000) show the relationship between text and event and serve as clues to the reader, facilitating the comprehension of meaning. In this study, the following linguistic marks will be used to clarify the elements of arguments: tenses, modes of discourse, argumentative operators, relations between sentences and lexical selection.

RESULTS

The analysis of the texts showed that the students use mainly substantive arguments, whereas scientists make use of analytical arguments. The use of different tenses, both in the scientific discourse as in the texts produced by the students, reveals the transformation of functional biology into a historical narrative. Functional biology refers to phenomena or processes related to living organisms, such as genetic or behavioral responses, and answers to the question "How?", which is usually answered by studies in the fields of genetics, physiology, developmental and behavioral biology. Instead, evolutionary biology answers "Why?" questions, which relate to the understanding of the historical causes underlying the observed phenomena or process, namely those leading to new or modified genetic programs. Normally it is constructed as an historical narrative (Mayr, 2005).

Lexical selection and the use of qualifiers in the arguments set forth by both groups, students and scientists, revealed the shift from alethic modalities – which refers to the *truth* about a state of things or objects of thought – to epistemic modalities – those referring to *knowledge* of a state of affairs or object of thought. The epistemic modality appears only in the discussion of results in the writings of scientists. The analysis of their content shows that statements, conclusions and mainly questions requiring further testing can be only understood and verified by those working with science. When this scientific discourse is re-contextualized in a biology class, the alethic modality, used by scientists predominantly in the conclusions and presentation of results, is the modality used by students in their discourse.

DISCUSSION

The production of scientific knowledge occurs at different levels. Initially, scientific articles are produced, showing results for specific questions. For example, the article by Avery presented here shows that the substance responsible for changing transformations in bacteria is the DNA; and the article by Hershey-Chase concludes that DNA has a role in the reproduction of bacteriophage T2. In a second step, the scientific community relates these results to more general theories, in this case generalizing the function of DNA as the carrier of hereditary information in living beings. So for the lay public to have access to this general claim, their development and review within the scientific sphere were necessary. It is only after this hypothesis is scrutinized and tested by scientists that it escapes the boundaries of the scientific culture and undergoes re-contextualization into other spheres, such as education.

In the boundaries of school culture and science lay down scientific truths as known by the general public. The way a scientist access these truths is different from that used by students. To make a general claim, scientists delineate and implement scientific experiments and predominantly use analytical arguments in which data collection is valued; in those arguments there are implicit *warrants* and basic knowledge shared by the scientific community. The data collected might, only then, be considered as facts, from which deductions can be made.

In the classroom activity analyzed here, the teacher made general allegations and asked the students to justify them, making the *warrants* that justify the relationship between *data* and *conclusion* clear*;* in other words, they were asked to elaborate substantive arguments.

When one is part of a community, some of the assumptions connecting data and conclusions may not be tested and/or made explicit. However, at school, students are evaluated precisely by the understanding of these assumptions, so their explanation in an appropriate manner is required. The literature in science education emphasizes the development of substantive arguments by the students. Jiménez-Aleixandre and Díaz de Bustamante (2003), for example, perform their analysis only with those arguments considered substantial, or that require knowledge of the content and respond to problems posed in the classroom.

The existence of scientific "truths” in the zone of hybridization between the scientific and school cultures is associated with conceptions of science that take into account the process of building these truths, the notion that they may be provisional and subject to testing, the human and fallible nature of scientific knowledge and the degree of success in the explanation that is proposed. While these truths are expressed through the alethic modality, the view of science as transitory can be expressed by the epistemic modality. We verify in this analysis that the border zone between school culture and scientific culture reveals the use of both types of modalities, but with elements of each of them that are restricted to the practitioners of each sphere.

The analysis presented here suggests that the route taken by students to access scientific truths or construct conceptions of science involves stages and processes that are different from those employed by scientists. If, on the one hand, it is not sufficient for the purpose of science education to enable the understanding of results and conclusions produced within the scientific realm, on the other, not all rules are accessible to students. Thus, science education must be seen as a process of constructing an idiosyncratic view of science that involves the understanding of its concepts and language, not by adopting this new culture, but by interacting with it.

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A COMPARATIVE STUDY OF THE SEMIOSIS PROCESS IN PHYSICS TEACHING

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Abstract : This study is comparative, it aimed at achieving a better understanding of four features of the didactic semiosis i.e. the way teachers and students produce and recognize signs of various forms in order to teach and to learn: (1) The first feature is the semiotic systems that the teacher uses to represent different aspects of the knowledge at stake. The second one lies in the verbal discourse that enables the teacher and the students to acknowledge the same signs in a similar way. The third one refers to the actual didactic experience, in particular the bodily experience, in which the semiosis process takes place. The fourth one specifically focus on the way conceptual models of Physics in the classroom (the change of state of matter and the Inertia principle) are involved in the semiosis process. We present two teaching design experiments, at kindergarten, where we study the change of state of matter, and at 9th Grade, where we study the Inertia Principle. For each feature mentioned above, we present first an analysis focused on each level, then a comparison. We show how the teacher's and students' joint action relies on the semiosis process, through a dialectic relationship between the didactic contract and the didactic milieu.

Keyword: Semiosis, Joint action, Didactic resources, Design, Classroom

INTRODUCTION AND RATIONALE

We consider that discourse, argumentation, and epistemic practices take place within a semiosis process. The importance of semiosis has already be underlined in relation to an approach in terms of action and in strong relation to learning (Jewitt & al. 2001; Lemke, 2002; Kress, 2008). This semiotic process in science education takes place in the framework of school and classroom and we name it, the didactic semiosis that is the way teachers and students produce and recognize signs of various forms in order to teach and to learn. Four features characterize it. The first feature is the semiotic systems that the teacher uses to represent different aspects of the knowledge at stake. The second one lies in the verbal discourse that enables the teacher and the students to acknowledge the same signs in a similar way. The third one refers to the actual didactic experience, in particular the bodily experience, in which the semiosis process takes place. The fourth one specifically focuses on the way conceptual models of the taught discipline in the classroom are involved in the semiosis process. This last feature is specific of what is taught, in our case it is physics at two different levels, Kindergarten and grade 10. Thus refering to epistemological analysis, we argue that the didactic semiosis relies on various forms of representations, in Hacking's sense (Hacking, 1983). Such a system of representations plays a prominent role in elaborating a Physics *Thought Style* (Fleck, 1979) within the classroom (Sensevy, Tiberghien, et al., 2008). In this presentation, we use a comparative method in order to understand how the semiosis process unfolds in a systemic way at the two different school levels kindergarten and 10^{th} grade. This study is a first step of the research project.

METHODS

In both cases, the teaching sequence was designed by a group of researchers and teachers.
At kindergarten, the change of state matter: We focus on an exploratory research (Sensevy, 2010), in which the research team worked on the change of state matter at Kindergarten in a "lesson studies" design. The main conceptual goal of the study was students' understanding of what is permanent through the change of state matter. We used different semiotic systems, including a "paper thermometer", a diagram differentiating "liquid water" and "solid water", and a molecular representation of "liquid water" and "solid water", relating to verbal language.

At 9th grade, the Inertia Principle: We designed a teaching sequence on mechanics (grade 10) (Tiberghien et al., 2009) in which we first introduce the notion of action associated to a *diagram called system-interactions* where the object (or system) is represented by an ellipse, a contact action by a full double arrow, and a distant action by a dotted double arrow. Then the concept of force exerted by a system on another one with its vector representation is introduced before the Inertia principle. Thus the concepts and the experimental facts are clearly distinguished; the action is associated to the fact that an object is acting on another one and force is the concept that models this action.

Collected data

In both case studies, the main data are video recordings of the classrooms and two cameras were used. In Kindergarten, the team research implemented two successive versions of the same learning session. The teacher was a primary school teacher (and teachers educator) of the team. In mechanics, a grade 10 physics classroom was videotaped during the dynamic part of mechanics teaching (7 sessions); the teacher used the designed teaching sequence.

We do not develop our methodology of analysis, we just mention that our analysis is carried out at different levels, going from a micro level of gesture analysis to a more global levels *and* the reverse; that is "zooming" in and out (Lemke, 2001; Roth, 2001)

RESULTS

We present our results first at kindergarten and then at grade 10, to show how the specific resources designed in the respective teaching sequence presented above allow students constructing and sharing new meanings.

Kindergarten: A major stake of the teaching experiment was that the students had to be able to relate the different states of matter to the measurement of temperature. In order to do that, the research team designed a teaching sequence in which the habit of daily temperature measurement was grounded on a "paper thermometer" (figure 1). This artifact was used in order to allow the teacher to "reproduce" the real temperature measurement, and to analyze it, namely by using the "zero" point as a distinctive feature of this process. This device allowed the students substantive meaning making progress, for example in the mathematization of their experience of "cold" and "hot", through the negative and positive temperature. The teacher and the students need to acknowledge a common vocabulary in order to be able to characterize their experience and to draw joint inferences of the common background linked to this vocabulary. In the class discussion, the expression "liquid water" and "solid water" were used. The situated mastering of this distinction allowed an evolution from concrete meanings to conceptual understanding. In particular, the teaching design organized a specific relationship within a semiotic system representing on the same diagram a model of the paper thermometer in front of each state of mater. In doing so, the teacher institutionalized the link between the "relevant" terms and the "accurate" temperature measurements. In the refinement process in which the research team was involved from the implementation of the first version to the second version of the design experiment, we met the following difficulty. The students were confronted first to "liquid water", then to "solid water", without being directly confronted to the change process. The research team dealt with this issue, in designing a situation in which the students' bodily experience played a prominent role. The students hold ice cubes in their hands, in order to let these ices cubes melt. In doing that, the students directly experienced the fusion phenomenon from the "solid water" to the "liquid water".

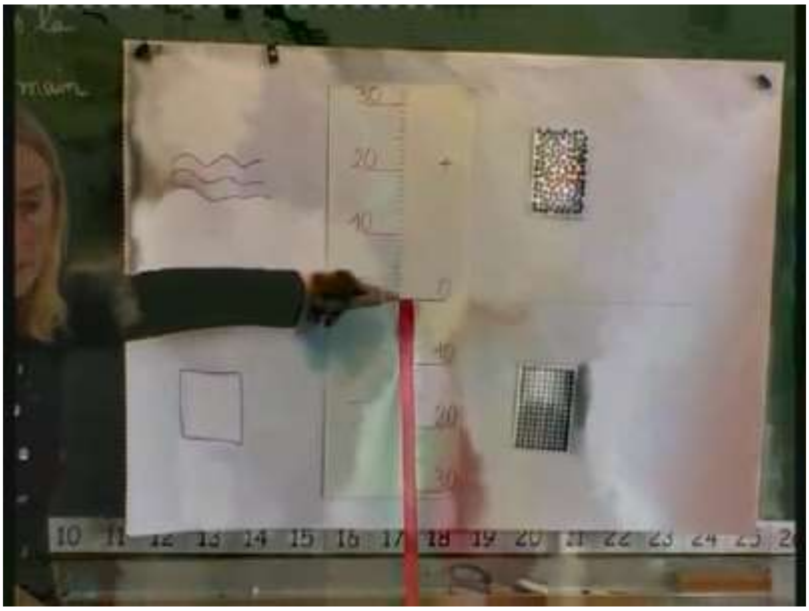

Figure 1: The paper thermometer (the red line can move according to the measured temperature)

At the end of the teaching process, in the first version of the design experiment, the team research noticed a lack of explanation for the phenomena of change of state of matter in students' verbal productions. The team research decided to ground the second version on a molecular model we presented to the students. This molecular model was added in a general "parallel diagram" in which was represented in an interrelated way i) the terms "liquid water" and "solid water", ii) the representation of the temperature measurement for each of these state mater, iii) the molecular model corresponding to "liquid water" and "solid water". This "complex" representational system allows the teacher and the students, in their joint action, to link verbal utterances, semiotic system, and conceptual model, by relying on memories of students' bodily "melting" experience. This system enables the teacher and the students to describe some parts of the system by using relevant utterances precisely relating to the diagram.

At Grade 10: A major stake of the first part of the teaching sequence was the notion of action in particular in motionless situation where no change is perceptible. This notion was associated to the system-interactions diagram that allows representing a variety of familiar situations where objects are motionless or moving in the same way. During this first part, some difficulties appeared, in particular the distinction between the action of the ground and that of the Earth. For example in the case of the actions exerted on a table on which a book is placed, whereas all students proposed the action of the book with a full arrow, a part of them proposed the distant action of the Earth (dotted double arrow) and the other part proposed the action of the ground (full double arrow) (figure 2). This difference in the diagram (full or dotted arrows) helped students to be aware of the differences between the two proposals and favours debates when students were working in small group and also at the whole class level with the teacher who fostered the debate. In these debates, the students understood each other easily to the extent that the rules of the diagram and the language associated were shared by all students; they mainly used verbs of action of the common language but they used the verb “to act” of which the meaning has been extended to situations where no change is perceptible (contrary to the everyday language).

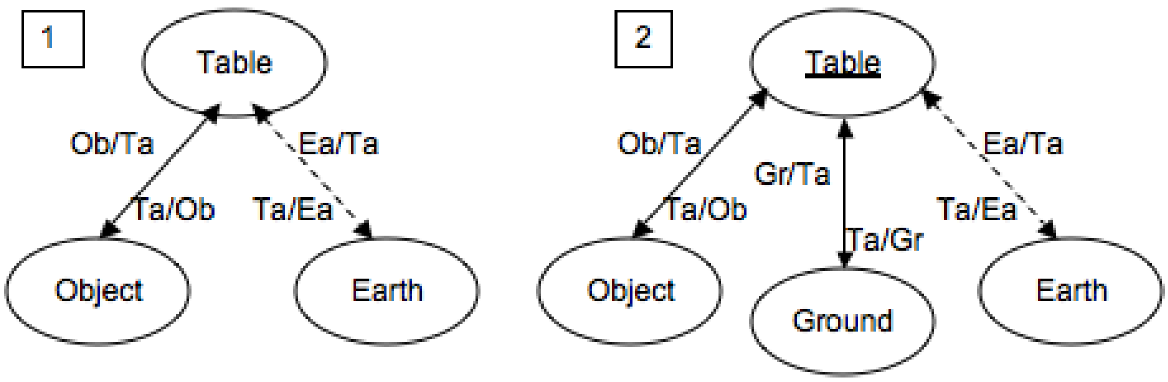

Figure 2 : part 1: student’s solution, part 2: correct solution

Most of the studied situations were very familiar to the students, but they required students to look at them and spoke about them differently. Just after these activities, the teacher introduced the direction of action with new activities where the students had to launch and received a medicine ball and thus had to perceive the direction of actions of their hands, in particular they had to differentiate the action of the hands and their motion when they received the ball. Here the reference to their bodily experience helped students to debate with an understanding of the various arguments. After these activities, the students were introduced to the concept of force including its vector representation. Force was exclusively used (at least by the teacher) as the concept and not to describe the effective actions of objects. In this teaching sequence, the distinction between the events and the concepts was clearly made in the verbal language and in the semiotic representations of the force vectors where the objects are represented by points, with no mixture between the drawings of the effective situations and the force schemas. This clear distinction between material situations and the physics model of force was made easier because of the introduction of the diagram system-interactions. This diagram is a didactic construction only; physicists do not use it. It is an intermediary between the abstract conceptualisation of force and its vector representation. Thus during this teaching sequence,

CONCLUSION: A COMPARATIVE DISCUSSION, FIRST ELEMENTS

The two design experiments may be analyzed as relying on the same way of considering representations. 1) Some semiotic systems are used as *public* representations (Hacking, 1983) in order to conceptually characterize some fundamental *differences* physicists make in order to understand the world (for example diagram system-interactions; diagram thermometer-solid water/liquid water). 2) These semiotic systems are not only used in themselves, but they function as parts of larger representational systems (for example diagram system-interactions was related to the force model; diagram thermometer-solid water/liquid water was related to the molecular model in a “parallel diagram”). 3) These representational systems organize a specific seeing-as (Wittgenstein, 1997), which is the main feature of a thought style (Fleck, 1979) (for example seeing action in a motionless situation; seeing the liquid water as the same matter composed with the same molecules as the solid water under different temperature conditions). 4) These representational systems institute some precise relationships between verbal language and semiotic system, and allow systematic correspondences between particular utterances and specific semiotic structures (for example verbal representations as “the Earth acts on the table” precisely relating to the dotted arrow; verbal representations as “when temperature is below zero, the water is solid water, the water molecules are very close each other”, etc. precisely relating to the parallel diagram). 5) These representational systems are worked up in an embodiment process which enables the students to achieve a bodily understanding of some dynamic aspects of the representational systems (for example the students’ medicine ball experience helps them to understand the direction of actions; the students’ melting experience helps them to understand what is permanent through the change of state matter). 6) These representational systems provide a common background which foster epistemic argumentation and discussion in the classroom. We draw a main implication of our research with respect to the design of teaching sequences in Physics that lies in the necessity to build representational systems grounded on *systematically related* verbal and semiotic representations, with the help of the students’ bodily experience of some scientific meanings. We argue that such a didactic semiosis process enables the students and the teacher, in their joint action, to share both a concrete and an abstract understanding of the models of Physics.

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QUESTIONS IN SCIENCE TEXTBOOKS: DO THEY PROMPT STUDENTS' INQUIRY AND PROBLEM-BASED LEARNING?

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Abstract: Problem-based learning (PBL) is an inquiry-based learning approach that fosters the development of students' autonomy as learners, and enables them to develop life-long learning competences. Problems and their underlying questions are building blocks of PBL approaches. Thus, questioning in science classes and textbooks can foster the development of students' inquiry and problem-solving competences. As teachers' teaching practices seem to depend on textbooks, this study compares the way the three Physical and the three Natural Sciences most sold textbooks deal with questions when developing the Earth in Transformation curriculum theme. This analysis focuses on: localization and function of the questions; nature of the answers demanded; and cognitive level of the questions. Results reveal that: only Natural Sciences textbooks use questions in the opening of the theme and its units; Physical Sciences textbooks have larger numbers of questions than the Natural Sciences ones do, being most of them connecting and knowledge application questions; both subjects' textbooks are similar in what concerns using questions as section titles and giving explicit answers to questions; Physical Sciences textbooks have a much larger number of non-guided answer demanding questions; whatever the subject, the number of high-level thinking demanding questions is low. These findings indicate that most science textbook questions can hardly promote student's inquiry and PBL.

Keywords: questions, science textbooks, inquiry, problem-based learning, Earth in Transformation

INTRODUCTION

School plays a major role in the formation of the individuals' personality, making them more responsible, better informed and more critical while ensuring that they will be able to use knowledge adequately. Studies indicate that it is impossible to ensure scientific literacy using traditional methods. As such, it is very important that the process of learning science becomes increasingly meaningful, relevant and interesting. It is equally imperative that students become more active participants.

Questioning is considered to be fundamental to the learning process as it encourages students to find solutions to different problems. One of the most important objectives of formal education is to develop students' autonomy as learners.Thus, it is important to understand the best ways to encourage and promote questioning by students.This requires high-level thinking as well as learning how to develop competences. Solving problems and answering to high level questions may foster the development of those competences (Wragg & Brown, 2001).

Problem based learning is an inquiry-based learning approach where problems play a major role acting as a stimulus for students' learning. This method uses daily problems as a point of departure for the learning process (Lambros, 2004). The problem is introduced at the beginning of the unit of study, ensuring that students know what they are learning and why they are learning it, thus increasing their motivation. In this way, all information gathered by students is learnt with the purpose of solving a problem (Chin & Chia, 2004). According to this method, the learning process begins with the identification of the problem itself. Students are confronted with a scenario generally related with the real world. The latter promotes debate among students as well as they resolve to discover something relevant to their personal daily lives. Students formulate questions that help to diagnose their knowledge and their difficulties. Through this process, students learn to identify their prior knowledge about a subject, their related learning needs, and the best way to solve the problem and achieve relevant knowledge on the subject (Dahlgren & Öberg, 2001; Chin & Chia, 2004). In an inquiry-based learning approach, students should question, examine books and other sources of information, propose hypotheses, analyse data, propose conclusions and communicate the results. As De Boer (2004) says, although students achieve different independence levels within this approach, students are indulged to develop their problem-solving capability, preparing them to be self-oriented and concerned citizens.

Questioning, either in science classes or in textbooks, can work as a privileged strategy for students to develop PBL competences. However, not all questions are useful for this purpose. In fact, only questions that require understanding and high order thinking can be useful within a PBL framework. Science textbooks include questions with different characteristics and purposes when they develop content topics.

Although the Portuguese Educational System Law (law number 49/2005, 30 August) advocates science textbooks as an important educational resource, research has shown that textbooks are conservative with regard to the way they develop curriculum themes, forgetting problems and questions as important ways to promote cognitive development (Leite et al., 2011).

As teachers' teaching practices seem to be dependent on textbooks, this research study compares the way the three Physical and the three Natural Sciences most sold textbooks deal with questions when developing the Earth in Transformation curriculum theme. Results may help teachers and teacher educators to become aware of the potential of textbooks as inquiry promoting tools within the scope of PBL and to find out ways of overcoming their limitations, if necessary.

Questioning

For Dewey (1933), a question is a way to evoke, to provoke or encourage inquiry.

A question may be conceptualized as an issue put forwards for discussion in such a way that it demands an answer. Hence, questions are associated with problems, as both include a sort of obstacle that needs to be overcome by the respondent or problem solver.

The formulation of questions is a frequent activity in our daily lives and also in the classroom. In the context of the classroom, the question is particularly important and even considered the essence of the learning process. It creates imbalances that encourage students to seek for new solutions (Giordan & Vecchi, 1996).

To accomplish their role as curriculum development mediators, school textbooks should foster the development of students' questioning and problem-solving abilities. There is some evidence that Portuguese school science textbooks include many questions, even though some of them cannot be associated to problems, as they do not require, at least, comprehension of the science issues (Dourado & Leite, 2010). Assuming that questions may be the start of a meaningful discourse, textbooks should use questions as a starting point for developing the curriculum theme, and its teaching units, sub-units or sections, in order to foster students' cognitive and affective engagement with the issues to be addressed. Some textbooks do this more often than others but when they do it a few of those questions are left unanswered (Dourado & Leite, 2010).

Questioning has concentrated many researchers' attention and has been investigated from diverse angles, including questioning in the classroom, teachers' questions, students' questions, textbooks questioning, etc. Literature (Wragg & Brown, 2001) indicates that: teachers ask too many questions, and that most of them are not only low level questions but also questions that are not supposed to be answered by the students; students are not used to be asked to formulate questions but when they have the opportunity to do so, they do it very satisfactorily. However, the cognitive level of students' generated questions seems to depend on the characteristics of the problem context that elicits them (Dalghren & Öberg, 2001).

Several question taxonomies emerged from research undertaken. Some of them draw heavily on the cognitive requirements of the questions and follow Bloom's Taxonomy of educational objectives; others pay some attention to procedural competences and therefore combine cognitive-based and procedural-based categories; others include also value-laden categories. Dalghren & Öberg (2001) defined a taxonomy of students' formulated questions that follows the latter pattern. It includes five categories as follows: Encyclopaedic Questions, demand an unambiguous and not complex answer (e.g., What is a fossil?); Meaning-Oriented Questions, oriented towards finding a phenomenological meaning of certain terms or concepts (e.g., How can the study of meteorites help to understand the structure of the Earth?); Relational Questions, focus on relationship between aspects/ features (e.g., What is the relationship between the different types of rocks?); Value-Orientated Questions, demand for a judgment based on some criteria (e.g., To what extent is nuclear energy a safe alternative to fulfil the world energy needs?); Solution-Oriented Questions, focus on looking for solution(s) for a problem (e.g., Write an essay on the energy crises focusing on what can be done in order to reduce the excessive use of fossil combustibles and the energy crises).

METHODS

To attain the objective of this study, the three Physical (PS) and the three Natural (NS) Sciences most sold (in 2010/2011) textbooks dealing with the Earth in Transformation curriculum theme were content analysed. The analysis was based on a checklist based on Dahlgren & Öberg (2001) and Dourado & Leite (2010)). The analysis focused on the questions included in the selected textbooks but excluded questions given within learning activities (e.g., questions on data analysis of a given lab activity included within the lab worksheet). Data collection was done by two of the authors, after a deep discussion of the checklist. Due to space restrictions, quantitative results will be presented per subject only.

RESULTS

Physical Sciences textbooks include a larger number of questions than the Natural Sciences ones (table 1: PST- 403; NST- 135), due to their large number of application questions (242).

As shown by table 1, Natural Sciences textbooks present questions when opening the theme or its units. This is consistent with a PBL approach. Whatever the subject, textbooks use questions as section titles and to guide students with regard to expected learning results. This is consistent with an inquiry perspective and relevant for guiding students through the sections too. As far as the nature of the answer demand is concerned, the two groups of textbooks are similar except in that the Physical Sciences ones give guidance to students to answer to a large number (272) questions and Natural Sciences do not.

Table 1. Number of questions per dimension, category and subject

Dimensions of analysis	Categories | sub-categories		NST (n=135)	PST (n=403)	Total (538)
Localization of the question	Opening of the theme		9	0	9
	Opening of Units		31	0	31
	Title of sub-units		0	27	27
	Title of sections		49	36	85
	Throughout a sub-unit or section text	Integrated into the content being presented	5	39	44
		After the content presentation	1	242	243
		Resolved questions	0	12	12
		Other	2	0	2
	Associated to learning activities	Activities title	30	1	31
		Activities statement	8	30	38
	End of the sub-unit or section		0	16	16
Function of the question	Present expected learning results		40	27	67
	Present the text to be developed		3	36	39
	Link parts of a text on a given issue		53	39	92
	Present learning activities	Explicitly optional activities	2	0	2
		Explicitly compulsory activities	34	31	65
	State knowledge application activities	Explicitly optional activities	1	16	17
		Explicitly compulsory activities	0	242	242
	Illustrate problem solving processes		0	12	12
	Try to keep readers' attention		2	0	2
Nature of the answer demand	Answer ignored		4	9	13
	Answer given	Explicitly	118	122	240
		Implicitly	8	0	8
	Answer required to students	Without guidance	0	0	0
		With some guidance	5	272	277

It should also be emphasised that, whatever the localization of the questions, the cognitive requirements for giving a successful answer to most of them are very low, as most questions are encyclopaedic (table 2). Relational, value-oriented and solution-oriented questions were hardly found.

Table 2. Cognitive level of the questions according to their localization in the textbooks (f)

Localization of the questions	Types of questions									
	Encyclopaedic		Meaning-		Relational		Value-oriented		Solution-	
	NST	PST	NST	PST	NST	PST	NST	PST	NST	PST
A	9	0	0	0	0	0	0	0	0	0
B	16	0	9	0	5	0	1	0	0	0
C	0	11	0	16	0	0	0	0	0	0
D	43	16	4	20	1	0	1	0	0	0
E	1	25	3	14	1	0	0	0	0	0
F	0	184	0	57	1	0	0	0	0	1
G	21	0	5	1	2	0	2	0	0	0
H	0	14	0	15	1	0	7	0	0	1
I	0	5	0	11	0	0	0	0	0	0

Legend- A: Title of the theme; B: Title of the unit: C: Title of the sub-unit; D: Title of the sections; E: throughout a sub-unit or section text (integrated into a text being presented); F: throughout a sub-unit or section text (after content presentation); G: associated to learning activities (activity title); H: associated to learning activities (activity statement); I: end of sub-unit or section.

This result may be due to the fact that traditionally textbooks in Portugal don't include many problems or questions for students to solve or to see how they can be solved. In addition, the Portuguese curriculum is not a Problem-Based Curriculum, fact that does not help teachers to embrace problem solving or demand students to question.

CONCLUSIONS AND IMPLICATIONS

Physical Sciences and Natural Sciences textbooks differ in what concerns the number of questions they include as well as with regard to the way they use the questions. Although both groups of textbooks seem to acknowledge an inquiry based approach, Natural Sciences textbooks seem more consistent with a PBL approach as they use questions as the starting point for developing the theme and its units. On the other hand, even in Natural Science textbooks, most of the questions are encyclopaedic demanding a low cognitive level to give a correct answer. However, research is needed in order to find out how the textbook authors deal with those opening questions, especially in terms of what is supposed to be done and by whom to answer them. To analyse the answers given to these questions is a relevant issue for a deeper judgement of the potential of textbooks as PBL promoters.

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DISCOURSE IN SCIENCE TEACHER EDUCATION: A METHODOLOGICAL APPROACH TO SEGMENT DISCOURSE IN LEVELS [1]

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Abstract: In this paper we address the problem of methods of discourse segmentation, for discourse analysis, in science classrooms. Due to the specificities of the context of science teacher education, we argue for the development of specific methodologies to analyse discourse in these contexts. Thus, in this paper we describe a method that our research group has developed to segment science teacher classroom discourse in levels, adapted from Leont´ev's (1978) structure for human activity. This approach offers space for an iterative and reflective process of inquiry. Also, our method is grounded in sociolinguistic features such as contextualisation cues, which allows us to inquire from an emic perspective. In this sense, segmentation can be recognised by participants ("insiders"). From the structure of the activity proposed by Leont´ev, we derived the respective levels for discourse analysis (activity, action and operations levels) and we introduce the episode level between the activity and the action levels. We discuss why we introduced this additional level. We also present a whole schema to illustrate our method of segmentation for a selected analysis, which we made from a physics teacher education course. Finally, we discuss the status of this approach within the research field.

Keywords: Science teacher education; Discourse segmentation; Levels of analysis; Activity theory.

INTRODUCTION

Classroom discourse analysis is nowadays a consolidated field of research (Kelly, 2007). Although there is a substantial body of literature regarding discourse in basic science classrooms, relatively little research has been conducted into science teacher education. We suggest that methodologies to inquire into discourse in science teacher education contexts are needed, due to the specificities of such contexts. In this paper, we will present a method for segment discourse in the context of physics teacher education.

We consider it important that discourse analysis should be done at different levels, each one related to one type of discourse segmentation. This is justified by our consideration that discourse mapping at different levels is a relevant methodological approach to provide a basis for analysts to make inferences and interpretations informed by contextual feedback and sociolinguistic cues of different natures (e.g. Castanheira et. al, 2001). However, the traditional approach is mainly based on a time-scale criteria for discourse segmentation. As an alternative, our proposed approach deals with discourse segmentation from a psychological basis – Activity theory

Corresponding to such a perspective, our research group has focused on understanding the emergence of Discursive Didactic Procedures (DDPs) in the discourse in science teacher education contexts. Activity theory (Leont´ev, 1978) plays an important role to present and understand the DDPs from a situated perspective. From activity theory we developed a method to map discourse through segmentation at different levels. Each level is related to the others in an iterative and reflective process of inquiry. This method will be presented in the next section.

METHOD TO SEGMENT SCIENCE CLASSROOM DISCOURSE INTO LEVELS

Our method emerged from data gathered in a preservice physics teacher education course. The data is composed of 44 hours of audio and video recordings. Field notes were taken, and two interviews with the course teacher (hereinafter called "Teacher") were made: the first before the course began, and the second after it concluded.

In order to develop the discourse segmentation, we adapted the concept of units of analysis of one activity as proposed by Leont´ev (1978). Our choice is justified by the structural character of human activity that his proposal represents.

According to Leont´ev, any human activity can be analysed from different units: activity (related to a motive/need), action (related to the achievement of a conscious goal), and operation (related to conditions and methods of action accomplishment). For classroom analysis, we adapted this model to develop the levels of analysis (activity, action and operation levels) and added, between the activity and the action level, the level of "episode" (related to a common theme and to a chain of actions in which we can identify a temporal and logical sequence of beginning, middle and ending phases). The episode is not mandatory, because there is not always a thematic sequence of actions with beginning, middle and ending phases. The other levels are mandatory.

For each level, we have different criteria to determine a specific discourse segment. We will present these criteria briefly in the next sections, focusing on Teacher´s discourse.

Activity level (mandatory) – motive/need/main goal

Through readings from field notes, the analyst infers for each class a motive that emerges from Teacher´s need. The motive is an object (ideal or material) that fills one´s need, and that is a determinant for the activity level. Due to the fact that field notes can be read in a few minutes, this gives us a broad perspective of the events accomplished in one class. Thus, we chose to make inferences regarding activity (need, motive and a main goal) relying mainly on cues from field notes. Also, we defined one activity as one whole class.

Thus, with this information, we constructed a "Class Presentation Frame". Due to space restrictions, it is impossible to present any stretch of such frame here (and from other frames that will be mentioned later). For this, we refer readers to another work (authors, in press).

Action level (mandatory) – pragmatic goal

At this level, the analyst must define one main pragmatic goal for each action. The question that arises is: how can we segment the actions? Due to difficulties in distinguishing one segment from one goal, we chose to define the segment first and then assign one goal to it.

We made the decision to segment actions based mainly on contextualisation cues, a central concept of the sociolinguistic approach (Gumperz, 1982). This approach seeks to understand interactions and discursive meanings from an emic perspective (i.e., through the participants´

perspectives). The video was our primary reference for describing the boundaries of actions through contextualisation cues. Such cues mark redundantly changes in the content of speech, and changes in the flow of discourse. We call these delimited actions “clips”.

With such orientations in mind we constructed the “Narrations Frame” (authors, in press); and, we assigned modes of language organisation to each clip, which we call “discursive orientations”. This concept is adapted from literature on textual linguistics and text grammar (we recognise six types of discursive orientations relevant to science classroom discourse: argumentation, explication, description, narration, injunction and dialogue, see Adam, 1992; Werlich, 1976). Then, we made narrations of the ongoing discursive interactions for each clip. At this time, the analyst seeks to be more impartial. After this procedure, and through reading the narrations for each clip, a name is assigned to each clip in separate a column. The name represents an abstract for the particular clip and describes its main action. The analyst writes comments in the same column, and at this time the analyst can be more partial.

Based on the clip´s name and its narrations, the analyst assigns one teacher´s pragmatic goal for each clip in another column. In other work (authors, in press) we give more information about this pragmatic approach for deriving goals.

Operation Level (mandatory) – conditions and methods

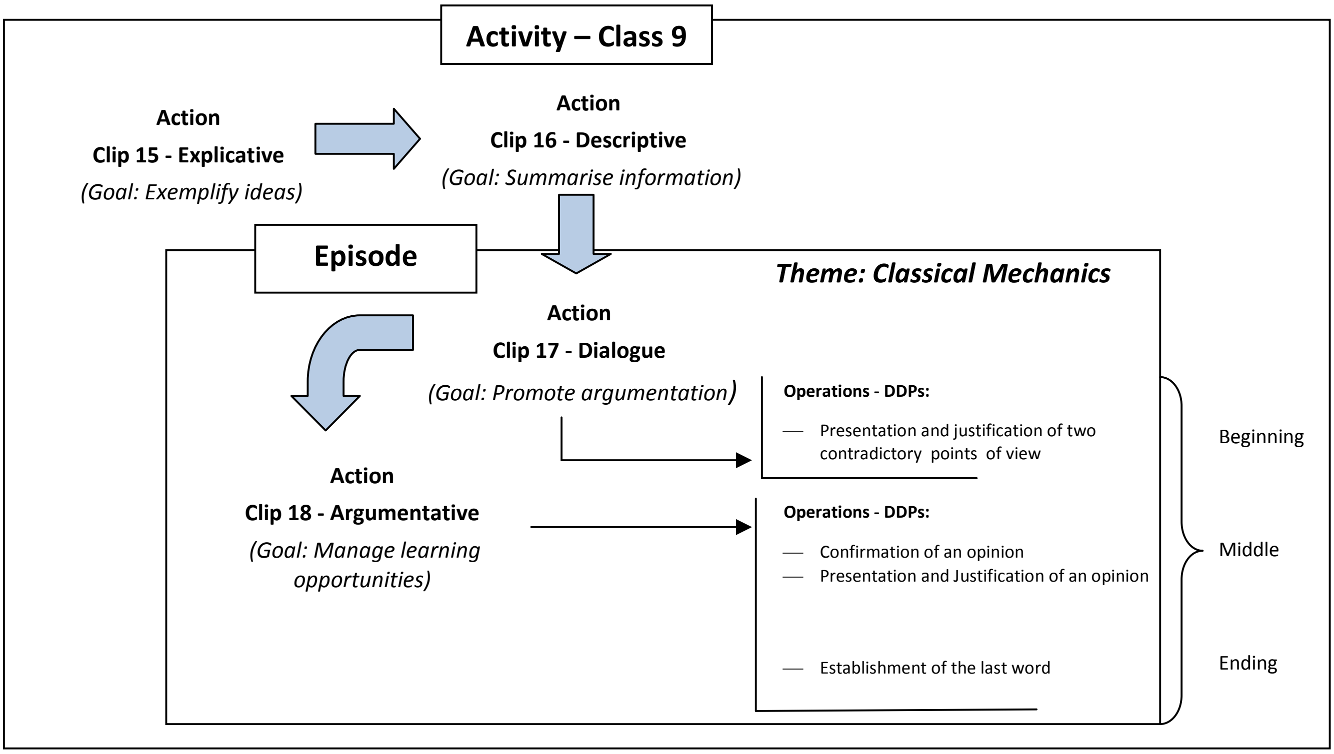
This level is related to the moment-by-moment interactions among participants. Operations are usually automatic and seek to satisfy the action goal to which they are linked.

It is at this level that we derive the DDPs, which are constituted by propositions (which are smaller units of meaning that can be identified in discourse). Again, such categorisation can be found in another work (authors, in press). The analysis process is taken into consideration to contextualisation cues, which are the main criteria for identifying the propositions. This process allows us to inquire from an emic perspective, because it is based on sociolinguistic criteria.

Episode Level (optional) – set of actions with a common theme and composing a whole with beginning, middle and ending phases

We added this level to the structure we adapted from Leont´ev. This level is situated between the levels of activity and action. Our choice is based on the assumptions that science classroom discourse is episodic by nature (Lemke, 1990), and that one action (clip) does not always constitute an episode. Dominant thematic content is central to this definition of episode. Also, our definition of episode requires the presence of a logical structure of beginning, middle and ending phases. Figure 01 illustrates these points: a class (activity), the clips (actions), some DDPs (operations) and the episode as the sum of dialogue and argumentative clips.

Figure 01: Representations of levels of analysis for class 9



DISCUSSION

Our proposal of the levels of analysis stands out because it is based on a psychological theory of human development – activity theory – and its adaptation to the specific context of science teacher education. In this sense, our approach is informed by, but also can inform, an activity theory perspective of human learning and development.

We consider that the process of analysis in levels is fundamental to an understanding of the "discursive rhythm" in science classrooms. In this approach, each level offers context and feedback with which we can understand the next levels. In addition, it offers interpretative cues and criteria for the selection of new events to be analysed. Finally, we consider that only future research that uses and makes adaptations of our proposed method of discourse segmentation in levels will be able to authenticate its flexibility and validation.

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PART 7: SCIENTIFIC LITERACY AND SOCIO SCIENTIFIC ISSUES

<u>*Co-editors:*</u> *Virginie Albe and Bob Evans*

Teaching about scientific literacy, science and citizenship education, science and media education, information literacy, informal reasoning and critical thinking, decision making, debates on socioscientific issues (SSI), discourse communities, social dimension of science and technoscientific practices, public engagement in science, schools', students' and teachers' engagement in socioscientific issues.

This part corresponds to strand 7. It contains 20 papers.

TABLE OF CONTENTS OF PART 7

SCIENTIFIC LITERACY AND SOCIO SCIENTIFIC ISSUES

INTRODUCTION

Research presented in this strand were dedicated to students' and teachers' attitudes towards science, technology, socioscientific issues or scientific literacy, discussions and /or decision making on SSI, school practices and science teaching on SSI, students' and teachers' reading of science stories, media and Internet. The articulation of media literacy to science education and the contribution of science education to citizenship education are then major issues addressed in the researches presented in this strand at ESERA 2011.

University students' decision-making on an environmental problem was investigated (Uksola, Maguregi & Jiménez-Aleixandre, 2011). Students had to select a heating system for a future building from among five possibilities. Decisions were made by students in reference to a normative framework adapted from Janis and Mann (1977). Students demonstrated their willingness to consider the advantages and disadvantages of the alternatives and their requirement of having information available before making a decision. Secondary school students' decision making on a friendly-environment energy were also studied within the implementation of a teaching unit on photovoltaic that included explicit decision making training (Knittel and Mikelskis-Seifert, 2011). Results showed a highly significant increase of students' knowledge and three main categories of decision making were identified. Students based their decisions on (1) intuition, (2) a cut-off or a list of benefits or (3) a trade-off. Evaluation strategies and content knowledge were also identified as playing a major role in secondary school students evaluation and judgment competence in chemistry (Hostenbach and Walpuski, 2011).
Ecological-oriented arguments were the less used by 13-14 years old students when expressing their decisions about the reintroduction of Bears in the Pyrenees (Domènech and Márquez, 2011). Students developed, on average, only one argument to justify their opinion, with a moral base or, more frequently a social base, with either a focus on humans or a focus on bears. Most of the secondary school students' implied in another study focused on three socio-scientific issues (energy crisis, global warming, water taxation) lacked scientific knowledge and considered the issues not as technical but as ethical problems (Mercan, Yakmacı-Güzel and Akarsu, 2011). SSI dilemmas, are apprehended by students as having their roots in human nature, manifested by the actions of individuals and governments. Students viewed human nature as extremely individualistic and highlighted the need for regulation by a higher political authority but do not feel confident on individuals and governments in their efforts related to SSI. Students felt doubt and despair about the possibility of solving the SSI dilemmas. Students' views on actions required towards the SSIs showed that while aware of political dimensions of the issues, and opened to taking pro-environmental actions, students do not considered themselves as active agents.
Science and mathematics teachers involved in a risk-based decision-making scenario related to surgery which includes elements of probability and outcomes tended to trust medical/scientific authority even though they acknowledge the uncertainties associated with this source of data (Levinson, Kent, Pratt, Yogui and Kapadia, 2011). Teachers decision-making process was justified with evidence-based reasoning but their decisions did not necessarily follow from reasons given. Teachers' explicated their personal models of risk which incorporated both rational assessments and values based considerations at a personal, experiential and social level.
Higher education French and Australian students discussions on a digital platform on environmental socioscientific issues for sustainability were studied (Morin, Simonneaux, Tyltler, Simonneaux, 2011). Three issues were submitted to students : a green algae outbreak along the coast of French Brittany linked to release of fertilizers, the construction of desalination plants to produce fresh water in Australia and consumption of meat. Types of discourse were identified within Mercer (1995, 2002) analytical framework : disputational talk, cumulative talk, exploratory talk and

domains of validity of arguments were identified in reference to Habermas (1987) worlds : objective world, social world, subjective world. Results showed a lot of cumulative talks. Morin et al. (2011) argued that the digital platform both support and constrain students' discussions, "with a lack of dispute in forums and wikis, and the problem of distribution of responsibility on the one hand, and with the value of the international forum in creating the requisite disturbance on the positive side."

Primary school students' attitudes towards technology were also investigated (Mıhladız, Duran and Yıldırım, 2011). Results showed no significant difference between students' attitude scores in terms of gender. Significant differences were found in students' attitude scores in terms of students' schools, grade levels and their families' income levels. Differences identified in attitude scores of students were found in favor of 6th grade students, the children of middle-level income families, and students of the schools close to the middle-level socio-economic levels.

In another study, high school students prior knowledge about mass extinctions and loss of biodiversity was identified (Almeida, Vasconcelos and Torres, 2011). Science and literature students showed knowledge they gained from generalist media (TV, Internet and Press). Science students showed a better perception of the catastrophic way that extinctions took place and a higher coherence in the selection of the causes of these extinctions. Students showed major difficulties in locating extinctions correctly in a geological scale time with science students achieving higher results. Students identification of endangered species were very similar between the science and literature students, showing that some students hold wrong information.

Media literacy is an aim that is articulated to scientific literacy in several works.

One approach is based on the idea that science fiction could offer significant contributions (Stavrou & Skordoulis, 2011) to improve the capacity to reflexively assess new and emerging technologies and the social dynamics of socio-technical systems (Miller & Bennett, 2008). Research was conducted with primary school students examining whether they can identify the issues raised by the ethics, moral and political aspects of Technology (Nuclear Technology, Biotechnology, Information Technology and Computer Technology) through analysing science fiction texts (short stories). Results show that students can identify the elements of the texts referring to the positive and negative aspects of technology concerning the ethical and moral issues related to society. The majority of students mentioned the 'dual use' of technology. In addition, they associated the use of technology to matters of politics and power, even when the text dealt with subjects the students were not familiar with. In addition, students were at ease writing science fiction stories of their own. In their writings, students raised societal, ethical and moral aspects of technology especially, as far as the use of technology as a solution to environmental or health problems is concerned (the hole in the ozone layer, cleaning the polluted seas, medication for the poor).

Another study focused on how a module on scientific and media literacy can initiate student–teachers' thinking and actions to handle media science information, to get familiar with current knowledge and debates and to produce teaching material about a new scientifically contemporary topic, the stem cells (Spiliotopoulou and Papantoniou, 2011). Future primary teachers searched and selected media material in order to get informed about the topic of stem cells. The further goal was to develop awareness on the stem cell issues in order to build a teaching unit about stem cells for primary students of 6th grade. Results showed that the controversies documented by the future teachers were related mainly to socio-ethical issues on private stem cell banking, while the issue of ethics concerning embryonic stem cell use was almost absent.

Findings showed that student-teachers accessed a substantial number of media, mainly electronic sources. The public domain of science as portrayed in student-teachers' collected material seems to affect the kind of thinking they develop and also their teaching plans. Private stem cell banks' sites seem to be a major source of information for student-teachers, though few sources can be considered reliable. Their awareness of socio-scientific issues of this nature needs further development and evidence suggests that there is a need for more specific guidance to be included in the teacher education course activities.

The critical reading of two newspaper articles with scientific content by students aged 15 to 16 was also assessed (Oliveras, Márquez & Sanmartí, 2011). The newspaper articles dealt with the difficulty involved in removing graffiti on glass and the opinions for and against whether the swimsuits used by swimmers had helped improve the latest Olympic records. Results showed that identifying the writer's purpose and identifying data and evidence given in the text were tasks students found the most difficult overall. These results were interpreted in relation to students representations of the media. Students were mostly convinced that the purpose of the text was to inform and that this information is always neutral and unbiased.

Research also focused on the potentialities of a socio-critical and problem-oriented approach to science teaching as a basis for learning about assessing information (Eilks, Marks and Burmeister, 2011).

Teachers conceptions of scientific literacy, of values related to scientific literacy and viewpoints on SSI implementation in class were also studied. It is apparent that secondary school science teachers read and interpret curriculum in ways that match their value set (Cooper and Corrigan, 2011). This influences their notion of scientific literacy and their teaching practice with a great coherence with their underpinning values.

Some difficulties in the implementation of SSI activities by pre-service physics teachers were identified (Bernardo, 2011). Lack of time and lack of flexibility of school programs were mentioned. The teachers' training and the interdisciplinary nature of the SSI perspective have also been identified as constraints for implementing SSI in class. Teachers indicated the role of SSI in catalyzing discussions hat promote the exercise of dialogue and argumentation by the students. However, results also revealed a tendency to prioritize actions in the classrooms that reinforced the development of arguments conveyed mainly through media or experts. A focus on communication raises the question of an potential effective contribution to a critical education of students.

How middle school teachers from various subject matters negotiate with SSI themes and contribute to citizenship education was also investigated (Barrué & Albe, 2011). Results showed a tension between a contribution to a citizenship education that focuses on civility and rules and a critical emancipatory citizenship education. The latter corresponds to the aim to develop pupils' skills such as searching and evaluating information, developing argumentation and critical thinking in order to be prepare pupils to build their own argued opinion and participation to public debates.

Interrogations were then also focused on understanding how science education may contribute to scientific literacy and citizenship education or civil society (Geiger, 2011). Participative democracy is an aim often called within the SSI movement and advocated in science education reforms at an international scale, but more research efforts are needed to document the potentialities or constraints of scientific literacy and citizenship education through science curricula.

Virginie ALBE & Robert EVANS

MASS EXTINCTIONS AND LOSS OF BIODIVERSITY: PRIOR KNOWLEDGE IN SCIENCE AND LITERATURE HIGH SCHOOL STUDENTS

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Abstract: The now ending International Year of Biodiversity put the issues of mass extinctions and the loss of biodiversity in the media agenda. Being aware that this issue is only addressed superficially in the Portuguese science curricula, the authors assess the related prior knowledge held by science and literature high school students. Indeed, several studies mention a relationship between science‟s prior knowledge and the choice of a science or literature course. So, a questionnaire was applied to 404 students of 12 classes from 6 schools from Lisbon and Oporto (Portugal) that included questions regarding the groups and the species that became extinct throughout the history of the Earth, the causes of these extinctions and the main informal sources available for gathering this information. All students revealed some knowledge on this issue. Science students showed a better perception of the catastrophic way that extinctions took place as well as of their causes. Regarding informal sources of information on this subject, the majority of students in both groups chose the generalist media (TV, Internet and Press) as primary source. More specific sources of science information, like science centres, scientific magazines or books, were less selected. In this study, there is no clear relation between prior knowledge and career choice, as results give evidence that prior knowledge is similar in science students and literature students. However, students‟ interest in science is one of the main reasons for choosing a science course. Authors claim that including this issue in school curriculum can develop students competence, as well as their attitudes concerning environmental problems.

Keywords: mass extinctions, loss of biodiversity; science high school students; literature high school students, prior knowledge.

INTRODUCTION

It is expected for science students to have a better scientific literacy than literature students, as they study science in school. Furthermore, it is supposed that their interest towards science may lead them to search for information, either in formal or in informal contexts of learning. In fact, as Masnick et al. (2010) indicated, “Interest in a subject leads to the acquisition of knowledge in that domain, which leads to competence in the tasks in that area, which in turns feeds continued interest” (p.653). However, several studies suggest that students‟ attitudes towards science decreases over time (Masnick et al., 2010*)*. Indeed, the ROSE international project states that there is a negative correlation between students' interest in science (currently low) and science test scores (often high). The ROSE project has shown this evidence when presenting the correlation of -0.92 in the answers given by students from over 20 countries stating that "I like the discipline of science more than any other discipline". Moreover, according to the Human Development Index, the more developed a country is, the fewer youngsters show interest in science (Sjøberg & Schreiner, 2005). On the other hand, literature refers to the importance of foster students towards scientific professions and mentions the importance of making students identify with practitioners in science fields (Masnick et al., 2010). It seems that some factors, (such as reduced competence in science) lie behind students (particularly women) deciding against a course and a career in science.

However, other reasons as social factors, decreasing feelings of competence in math and demotivating science classes may interfere with students‟ choice. Grazzia et al. (2011) mentioned that the interest in science is not only important as a precondition for successful learning, but has a major influence on students‟ choice for the field of study. The same authors also refer to the fact that science is often linked to enjoyment and personal value, which remind us the importance of the popularization of science and the enormous contributions of informal places to initiate students to have interest in science. Learning science in informal environments has grown rapidly in extension and diversity and informal education has acquired increasing importance as an element of promoting activities which enhance the public understanding of science and also as a complement to formal learning. A distinction is frequently made between formal learning (which might occur in the formal setting of schools) and informal learning (which could occur in informal environments) (Anderson, Lucas & Ginns, 2003). Prior knowledge is generally acquired in out-of-school learning experiences such as museums visits, field trips, zoos, aquariums, nature centres or other informal settings. Although the growing body of research on learning in such free choice situations is increasing, there is a clear lack of learning studies from film, radio, community-based organisations such as scouts, summer camps, home, friends, the workplace, the Internet and a whole range of other real-world situations (Dierking et al., 2003). On the other hand, some authors claim that learning may continue well past the time span of a learning experience in an informal context. (Anderson, Lucas, Ginns & Dierking, 2000; Rennie & McClafferty, 1996). Hence, even in school settings, students are frequently exposed to learning in informal contexts, such as field trips or planned visits to other learning institutions. This idea emphasizes the importance of prior knowledge in the process of developing scientific literacy, increasing the attention of educators and curriculum designers. The question is to what extent prior scientific knowledge (acquired spontaneously in informal contexts) and the inherent scientific literacy may have a role in an important decision such as educational and career vocational choices. It seems that the more we know about a subject, the more literate and competent we are and the more interested we will be in studying it more. The experiences students have in daily situations dynamically interact to influence the ways they construct not only scientific knowledge and understanding but also attitudes and behaviours. The fact is that if students do not enjoy studying science, then they do not choose scientific careers. This lack of attention regarding this item may be an aspect to consider when trying to promote the students‟ choices for scientific professions. Prior to any formal instruction, students have a great deal of experience that is relevant to the development of a very substantial body of knowledge (Sherin, 2005), helping students to learn within formal settings and possibly influencing their consequent scientific vocational choice. As so, Science‟s prior knowledge may play a decisive role when it comes to curricular subjects and career path choice. Students can choose the kind of non formal places they visited and they also react to TV programmes, newspapers and magazine articles about science issues, according their own interests. However, some international meetings (especially those environmentally related), and commemorative years (such as the International Year of Biodiversity, 2010), can arouse students for science issues, further broadening their prior interests.

Prior knowledge, Mass extinctions and loss of biodiversity

When we want to assess the prior scientific knowledge of students regarding a specific issue, for instance mass extinctions and loss of biodiversity, we cannot forget that we are dealing with a controversial issue. This, in turn, makes assessment even more difficult. As Claire and Holden (2007) stated, many aspects can be considered when qualifying an issue as controversial: the complexity of the subject/area, emotions strongly aroused, conflicting priorities and material interests, or conflicting values, opinions and interpretations especially between scientists or research teams. In the case of mass extinctions we can see this clearly by observing the opposition between two geological interpretations: the uniformitarism and the catastrophism. The first one lays its roots in Charles Lyell"s work that argues that geological changes occur slowly and gradually, without sudden discontinuities or catastrophes; the second one ascribes the end of a specific geological time to special and diverse events, very episodic and very limited in time. In spite of Lyell"s influence in the geological community, Ager (1993), in his book *the New Catastrophism: the Importance of the rare event in geological history,* makes a new interpretation of part of Lyell"s work, allowing those two perspectives to be conciliated. As such, as Alvarez (2000, p. 178) stated, "though no scientist doubts that most of the earth changes are gradual, geologists are now free to explore occasional catastrophic events that punctuated the history of Earth", as for instance in the case of dinosaurs" extinction. According to Benton (2008), the modern era of mass extinction studies began in 1980, with the publication of the proposal that the dinosaurs had been wiped out by the impact of a large meteorite or asteroid, on the Earth. The author also claimed that this proposal, with an immensely high heuristic value but that raised a storm of protest, re-established catastrophism at the core of geology. Although recognized as being the most well known extinction among Portuguese students (it is by far the most known of the big five extinctions), four other major extinctions were also identified: the extinction of the late Triassic; the Permian-Triassic extinction; the extinction of the late Devonian and the late Ordovician one (Benton, 2008). Most geology"s books refer to these five extinction events during the past 500 million years that stand out from the rest. However, another controversial issue related to mass extinctions has to do with the 6th great extinction that occurred in the last 50 000 years. In fact, there are many reasons that justify the interest for this great extinction: firstly, the fact of being so recent in terms of geological time; secondly, the selectivity of this extinction and finally because of the controversy related to its causes, as many researches refer to human activity as the main one. Martin (2005) indicated that this extinction occurred without any correlation to climate change or any other factor than the impact of human expansion across the planet. As our species dispersed over several continents and islands, the mega fauna was mostly destroyed. According to Courtillot (2002) the Pleistocene saw the extinction of two-thirds of all mollusks, gastropods and bivalves of Western Atlantic and Caribbean, and mammals in Africa were likewise affected. Apparently, the selectivity of the extinctions of the late Pleistocene continued during the Holocene. However, as Mackay (2009) stated, the negative impact of humans starts to reach others taxonomic groups, as a result of the emergence of agriculture and animals domestication. In fact, some researchers believe that we are currently in the early stages of a major decline in biodiversity caused by humans. To diagnose the prior knowledge in Science Students (SS) and Literature Students (LS) at the beginning of high school the authors designed the following research project. Note that in Portugal this issue is not contemplated in the science curricula of previous school years. Students only learn about the division of the earth´ history in eras, and discuss some main fossil processes. The authors also considered the controversial issues that still prevail in the scientific community regarding this issue. However, since 2010 was the year of biodiversity, a specific interest in this issue is justified, regardless the small contribution of formal education for its study.

METHODS

To evaluate prior knowledge about mass extinctions and loss of biodiversity in SS and LS, a survey questionnaire was applied to a sample of 404 students with ages ranging from 13 to 18, from the Oporto and Lisbon regions (the two biggest urban communities in Portugal). The majority of students were female (n=244) and the average of age was 15,2. Voluntary participation, rather than compulsory, was stipulated by the research team. After being given a small training, 12 high school teachers were made responsible for the questionnaire application. Students usually took 30 minutes to answer to a total of nine questions. With the exception of the seventh question, all the questions were closed ones, and students were asked to put a cross signaling in the right answers. Questions two, six, eight and nine were semi-closed, given the opportunity to the students to refer other alternatives to the given ones. The questions addressed the following issues: the causes of extinctions, the groups and species of animals already extinct, the geological period of their extinction considering a geological time scale, the groups and species endanger of extinction, the main causes of present-day extinctions, the reason why these present-day extinctions should be the addressed in informal contexts of knowledge, where students acquired prior knowledge about the thematic explored and the reasons for being in a scientific or in a literature course. After some literature revision the authors wrote the questionnaire and, for the purpose of content validation, a group of four science educators and high school teachers were asked to check the questions and to suggest necessary revisions. Following this procedure, a previous study with a small convenient sample was developed to help the validation of the questionnaire. To analyze the answers of the students according to the three research questions a descriptive statistic was made with software application PASW 19. Some content analysis had to be previously made in questions number two, six, seven, eight and nine.

RESULTS

As previously stated we purposely present the survey results question by question and discuss the evidences showed by SS and LS.

Question 1: Throughout Earth's history many living species became extinct. Do you think that extinction occurred due to: a) predominantly gradually over time; b) predominantly catastrophic and localized in time.

When asked about the causes of mass extinction, the majority of the SS (63,3%) mentioned catastrophic causes, while the majority of LS (71,3%) indicated that mass extinctions happened gradually. Catastrophic and Gradual causes were simultaneously considered by 1,9% of SS. According to these results, it seems that SS are more aware of the possible conciliation of the two perspectives.

Question 2: Which cause or causes can you identify as accountable for these extinctions: a) Scarcity of food; b) Impact of comet, asteroids / meteorites; c) Climatic changes; d) Natural selection; e) natural catastrophes, like volcanism and marine regression and transgression…; f) human activity with impact in environment; g) charges divine; h) Inversion of the magnetic field; i) Other reasons.

Regarding the main causes of mass extinction, the SS three most selected answers were: “natural catastrophes, like volcanism and marine regression and transgression…” (87,5%), “climate changes” (83,7%) and “comet, asteroid/meteoroid impact” (81,7%). The LS answers differed in only one of the three main causes indicated: “climate changes” (84,7%), “natural catastrophes, like volcanism and marine regression and transgression…” (77,6%) and “human activity” (65,8%).

Question 3: Select the species (or groups) of living beings (animals or plants) that you consider extinct:

In this question almost all students picked out the Dinosaurs. In fact, the SS three most selected answers were Dinosaurs (99%), Trilobites (96,6%) and Ammonites (93,8%) and the LS three most selected answers were Dinosaurs (93,4%), Trilobites (82,7%) and Mammoths (77%). Overall, SS selected more correct answers (67,9%) than the LS (60,5%) and less wrong answers (SS - 7,5% and LS - 7,9%). Bearing in mind that the differences are not very relevant, it seems that SS have a better knowledge about this issue.

Question 4: Attempt to locate the considered extinctions in time, filling the chart above:

In spite of having a reasonable knowledge about extinct species or groups, there were few students who actually were able to correctly locate this extinction in a geologic time scale (Table 1). However, SS had more correct answers than LS, with the exception of the Ammonites, Graptolites and Toxodon extinction location in time.

Table 1. Species or groups considered as extinct and location of the extinction in a geologic time scale.

	Science Students		**Literature Students**	
	Considered as extinct (%)	Extinction correctly located in a geologic time scale (%)	Considered as extinct (%)	Extinction correctly located in a geologic time scale (%)
Trilobites	96,6%	19,4%	82,7%	3,7%
Dinosaurs	99,0%	32%	93,4%	2,2%
Thylacine	13,5%	42,9%	17,9%	22,9%
Ground Sloth	26,9%	25%	22,4%	2,3%
Ammonites	93,8%	13,8%	73,5%	21,5%
Great Auk	36,5%	17,1%	40,8%	8,8%
Dodo	61,1%	32,3%	53,6%	16,2%
Mammoths	85,6%	14%	77%	8,6%
Graptolites	87%	6,6%	75,5%	9,5%
Toxodon	76,4%	3,8%	71,4%	5,7%
Saber toothed tiger	67,3%	24,3%	57,1%	11,6%

Question 5: From the list presented above, chose the species in endanger of extinction.

When questioned about endangered species, the three most selected answers by the SS were: “Iberian Lynx” (94,2%), “Giant Panda” (68,3%) and “Siberian tiger” (63%). On the other hand, the three most selected answers by LS were: “Iberian Lynx” (83,2%), “Polar Bear” (62,8%) and “Giant Panda” (61,2%). The SS presented a number of wrong answers higher than the LS, for instance in the case of the Emperor Penguin and the Golden Eagle (45,2% and 40,9% against 29,1% 38,8%). But the opposite happened with the Koala and the Kangaroo, with a higher number of wrong answers being given by the LS (39,3% and 22,4% against 38% and 15,9%).

Question 6: Which cause or causes can you identify as responsible for the current extinctions? a) Scarcity of food; b) Impact of comet, asteroids / meteorites; c) Climatic changes; d) Natural selection; e) natural catastrophes, like volcanism and marine regression and transgression…; f) human activity with impact in environment; g) charges divine; h) Inversion of the magnetic field; i) Other reasons.

The three most widely quoted reasons for present-day extinctions were “human activity” (SS – 96,2% and LS – 92,3%), “climate changes” (SS – 86,1% and LS – 78,6%) and “lack of food” (SS – 55,8% and LS – 44,4%).

Question 7-Many experts are concerned with the number of species that have become extinct. In your opinion, why is this so worrisome?

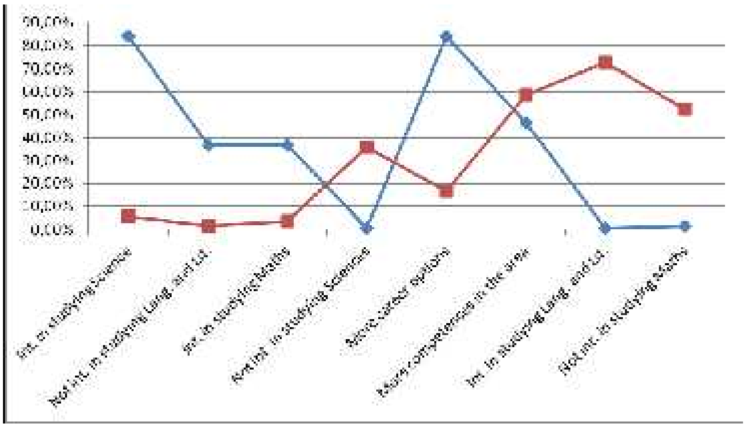
When we asked why present-day extinctions should be a matter of our concern, the main reason was the imbalance of the ecosystems (SS - 87,7% and LS - 86,8%) that can result in food chain rupture or changes in life circles caused by biodiversity reduction, which in turn can jeopardise earth‟s living beings, including humans. The second motive, referred by only 3,8% of the LS and 4,6% of the SS, points out to the lack of ethic and selfishness of Human beings. Due to anthropocentric reasons many species become extinct and many of those extinctions accelerated. Only 4,4% of the literature students and 4,1% of the science students referred to these 2 aspects simultaneously.

Question 8- As this thematic is not referred in school curriculum, how have you acquired knowledge to answer these questions: a) General Knowledge Books; b) Scientific Books; c) Television; d) Internet; e) Radio; f) Museums; g) Science Centers; h) Press; i) Scientific magazines; j) Friends; k) other reasons.

As for the main sources of information regarding this issue, the SS and the LS pointed out television (92,2% and 91%), the internet (59,3% and 63,7%) and the press (41,7% and 47,4%). Museums, Science Centers, Science Books and Radio stand out as other minor sources of information. Note that the Radio differed significantly in percentage (LS - 18,4% and SS - 5,9%).

Question 9: Select the main reasons why you have chosen to be in a science course/literature course. a) Interest in studying Science; b) Not interested in studying Languages and Literature; c) Interest in studying Mathematics; d) Not interested in studying Science; e) More career options; f) More competences in the area; g) Interest in studying languages and literature; i) Not interested in studying Mathematics; j) other reasons.

Regarding the reasons that are behind their choice, SS refer mainly to “interest in studying Science” and to the fact of Science courses offer “more options career” (84,3%). On the other hand, LS pointed mostly “interest in studying Languages and Literature” (72,8%), as well as having “more competences in the literature area” (58,6%) and “not having interest in studying mathematics” (52,3%) – Graphic 1.



Graphic 1. Reasons that lead the students to choose their course.

CONCLUSIONS AND IMPLICATIONS

Both the SS and the LS showed some knowledge regarding mass extinction, especially since it is an issue that is absent from the curricula of previous school years. However, the SS showed a better perception of the catastrophic process of extinctions and as such also revealed a higher coherence in the selection of the causes. Almost all the students of the two groups correctly identified the species and the groups that were extinct before the Cenozoic Era. The correct answers were less frequently chosen when referring to more recent extinctions, with the exception of the Mammoths. In either case, students showed major difficulties in locating extinctions correctly in a geological scale time. The SS achieved better results on this issue. Considering the identification of endangered species the results were very similar between the two groups, showing that some students hold wrong information. The informal sources indicated by the SS and the LS were very similar, with a focus in generalist media more than in science centres, scientific magazines or scientific books. This may explain why the global results between the two groups are not substantially different, and also consubstantiates the notion that formal context is still the more important context for obtaining scientific knowledge. Although the results showed some similarities in SS and LS prior knowledge in this issue, this study highlights the importance of students‟ interest in science in choosing a science course. In fact, the choice of a science course by SS is mainly due to their interest in science and their expectation in more career options. On the other hand, reasons like having more interest and competences in the literature area, as well as not being interested in studying math or science were given not to choose the scientific course. Giving the importance of this issue and according with the answers given in question 7, the authors think that it will be important to include it in a next curricular revision in such a way that it will allow the debate on the more controversial aspects, especially those ethical ones related to the 6th great extinction. This will contribute to the development of environmental responsible attitudes, increasing the science literacy and interest of young students in this issue while promoting the linkage between formal and informal education. This may also be a means of improving knowledge in other scientific subjects that are not addressed (or are superficially referred to) at school.

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NEW APPROACH IN FRENCH MIDDLE SCHOOL: A POSSIBLE CONGRUENCE BETWEEN SSI AND CITIZENSHIP EDUCATION

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Abstract: In a first time, this study aims at clarifying, who is the citizen targeted by French curriculum and what do they have in common with the one aimed by the Socioscientific issues (SSI) research movement. In a second time, questionnaires were submitted to teachers to examine how they negotiate with SSI themes and contribute to citizenship education. The analysis provided significant views of citizenship education: a citizenship education in connexion with civility and rules and a citizenship education to develop pupils' skills such as searching and evaluating information, argumentation and critical thinking in order to be able to build pupil's own argued opinion and participation to public debates. This last view is congruent with the critical emancipatory citizenship education generally promoted by SSI research.

Keywords: Socioscientific issues, citizenship education, critical citizen, middle school, teachers'practices

FRAMEWORK, BACKGROUND AND PURPOSE

Comprehensive access to scientific literacy has often been a goal for science education. Within an aim of science democratization, the education project is to equip citizens with skills enabling them to participate in society building with involvement in decision-making. Socioscientific issues (SSI) in science education research (Albe, 2008; Kolstø, 2000; Sadler, 2004, 2009) cover topics as biotechnology, environmental issues, sustainable development, energy choices...The argument that is generally promoted by the SSI research movement is a democratic participation. Although the aim of democratic participation of the population is relatively consensual, the reality seems more problematic in school context and Levinson (2010) recently raised the question of an uneasy congruence between science education and democratic participation. SSIs have been introduced in French schools through media events, official curriculum and specific teaching devices. In September 2005, the introduction of these issues was reaffirmed by new instructions in the official curriculum defining the called "convergence themes" common to several academic subjects forming the "wider scientific field" (mathematics, physics and chemistry, biology, technology, history and geography, citizenship education). The identified topics are: energy, environment and sustainable development, meteorology and climatology, statistical approach of the scientific world, health and security. They are described in the official curriculum in connexion with social issues and the educative goal is Citizenship Education (CE).

RATIONALE

This educative goal promoted by these new instructions converges with the declared SSI research aim which is generally citizenship education. This research is about the citizenship aimed to be developed: who is the citizen considered in the curriculum and targeted in the SSI research field? According to different perspectives of SSI research, emerging through literature reviews (Sadler, 2004, 2009; Albe, 2007) and some other empirical empirical papers (Colluchi-Gray, 2007 ; Gombert, 2008), this citizenship can highlight various trends. Firstly, the citizen can be involved in social and political action (Hogan, 2002 ; Patronis, Potari and Spiliotopoulou, 1999 ; Jimenez-Aleixandre et Pereiro-Munoz, 2002) through community of practices, which embody local associations for example. Following Hodson (2003, 2010) who calls for action, other researchers (Sperling and Bencze, 2010) advocated in favour of « activism ». For them science education may be considered in socio-political terms with the aim to assist childre to acquire skills for taking action to become involved as active citizen. Secondly the citizen can be considered as able to make reflective argued decisions, to evaluate the discourses of experts by understanding the Nature of Science and to participate to debates (Albe, 2008 ; Bader, 2003 ; Driver, Leach, Millar et Scott, 1996 ; Grace, 2009 ; Kolsto, 2000, 2001). Thirdly, It can be a citizen who should acquire scientific knowledge and be interested by scientific topics. Finally, in a marginal trend, a non-violent citizen resolving conflicts in a peaceful way can be aimed (Colluchi-Gray,2007 ; Gombert, 2008). Our research aims at clarifying what does the citizen aimed by the official curriculum have common features? And how teachers negotiate with SSIs via “convergence themes” to contribute to a citizenship education?

METHODS

As a first step a critical analysis of the conception of citizenship emerging from the official curriculum has been performed. The corpus was made of official texts: those relating to “social and civic skills” defined in the official curriculum as a part of *“everything that is required to master at the end of the compulsory schooling”*, those relating to “convergence themes” and those defining the academic subjects of the “wider scientific field”. In these various official documents, significant key words related to social and civic skills were identified, providing elements for understanding. This analysis allowed the identification of a citizenship profile, as targeted by the official curriculum.

As a second step, a questionnaire was built around 7 items addressing activities (1-2), practices for teaching (3-4-5-6) and teachers’ contributions, consistent with the different academic subjects through “convergence themes” (7a) and with citizenship education (7b). This seven item was attached to a short extract of official texts defining “convergence themes”. Questionnaires were submitted to middle schools teachers. With the aim to identify trends in teachers' contributions, a qualitative analysis has been conducted on the 69 answers. For the multiple choice question (1-2), a simple counting has been conduced and when the question calls for a written answer (the others), each answer was content analysed to build categories and sub-categories.

RESULTS

Who is the citizen aimed by the official curriculum?

He/she is firstly a citizen who develops attitudes and behaviors that allow him/her to be socially integrated through social codes, civility and who respect rules and laws. In addition the citizen has to feel a sense of belonging to his/her country and the European Union according to the official text defining “Social and Civic skills” and the specific contribution of historical and scientific academic subjects. This citizen has to be opened to other people and to the world,

adhering to values of tolerance and respect and taking part in community life. He/she must be aware of his/her rights and be responsible for his/her acts regarding security and health. The "convergence themes" as well as the academic subjects expand citizen's responsibility to environmental issues. A specific keyword named "choice" associated with social issues and decision-making on new technology is introduced, and the contribution of scientific and technological subjects to social, political and ethical decisions is considered. The citizen defined by official texts pertaining to "social and civic skills" has to engage in public life by addressing these social issues according to the official text of "convergence themes" that further legitimize citizen's participation in debates leading to decisions. According to the official texts defining "social and civic skills", commitment must be based on judgement and critical thinking in connexion with understanding of public argumentation, while official text defining "convergence themes" propose to built argued opinion in order to debate.
Different citizen features show a tension (fig 1) between two emergent profiles: on one side, a citizen recognised as a "virtuous" citizen who should have to acquire skills and behaviours to be socially integrated and on the other side a citizen recognised as a critical citizen being involved in choice and debate about society goals regarding issues having social, political and ethical dimensions. In the case, he (she) will have to acquire skills for "critical thinking".

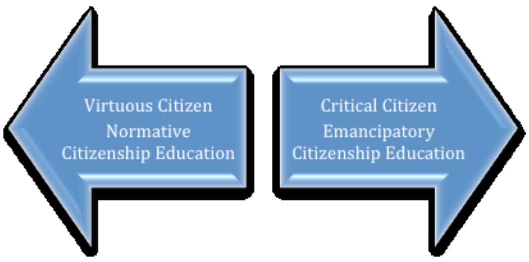

Fig 1

The curriculum analysis highlights a citizenship education oscillating between a normative education aiming at living together and a critical emancipatory education aiming at preparing pupils for decisions they will have to make in their future adult life.

How teachers negotiate with SSI via "convergence themes" and how do they contribute to citizenship education?

The distribution of the different teachers' answers to the questionnaire towards the choice of quoted convergence themes assumes a logic of academic subjects. For example, technology and physics teachers declared that they teach energy and sustainable development and biology teachers said they teach sustainable development and health. Regarding devices and practices of teaching, several teachers said they build special devices for this teaching. Some of them designed this teaching in relation with professionals. Some others designed this teaching outside academic courses as multidisciplinary devices. The answers show that teachers are aware of the necessity to involve different practices, according to the devices they design with other teachers of the same academic subject or with other persons. Still, when they were asked if they are together when teaching they answered negatively. Either they are alone, or they delegate to a professional participant working outside the school, whom they consider as most qualified to provide knowledge on selected topics. For the 7a item, three categories have emerged from our data analysis : teachers who tell they don't contribute to consistency between different subject matters; those who tell that they contribute to consistency by a collaborative work; those who refer to official curriculum. About their contribution to citizenship education (item 7b), a majority of teachers declared contributing to a citizenship education by developing pupils' behaviours, while others answered by developing new practices and a minority considered contributing by building pupils' skills. The majority of teachers expressed promoting pupils' attitudes such as civility, respect of rules, awareness of society's challenges. Several teachers underlined the necessity to change school practices and create activities that are meaningful because they contribute to a citizenship education rather than making learning a goal of its own. Their common thinking is to build a bridge between school knowledge and what they called "the real life". They considered that it is necessary to link teaching to pupils' everyday life to give meaning to knowledge, to develop debate practice about "convergence themes" which are identified by teachers as an un-established knowledge. Finally, a minority of teachers think they contribute to citizenship education because they try to develop pupils' skills such as searching and evaluating information, argumentation and "critical mind" in teachers' own words. Their aim is to form pupils to be able to build their own argued opinion. This view of citizenship education is the one we recognize as a critical emancipatory citizenship education.

DISCUSSION

Citizenship and citizenship education are complex issues that may not be considered with the same meaning in different countries. Although US, British and French citizenship, for example are not envisaged in the same way, an acknowledged link between citizenship education and SSI seems to be consensual for SSI researchers at an international scale even if different trends of citizenship views can be highlighted in SSI research literature. According to it, SSI research is rather in favour of pupils'empowerment, even if a hierarchy between SSI goals in literature research can be seen.

Data analysis of teachers' questionnaires shows congruence between teachers' views and citizen features emerging from SSI research literature. Teachers of the study seem torn between a normative and an emancipatory citizensip education. The majority of teachers who promote a normative citizenship education and a form of docility in regard to "good" behaviours can be recognized as the "virtuous citizen" having duties to others and community. The minority of teachers who promote a more emancipatory citizenship education try to contribute to a "critical citizen" building, joining the SSI-citizen, the one being able to participate to public debate and decision-making; the citizen having the will to be associated in debate and political decisions about society goals. Some questions emerge to teachers' answers about "convergence themes" teaching. They suggest that teachers are not prepared to support new practices and coach pupils in skills development and that they have to deal with a "nebulous view" of citizenship education presented by curriculum. We assume that teachers perhaps do not feel competent for this teaching or alternatively, that they show a willingness to forge links between school context and society. Official texts seem to promote intentions towards SSI but do not precise that teachers should have to develop different views emerging from society about such issues. So, teachers are not at ease to negotiate with these issues because educating citizen to participate to society choice is more complex than teaching traditional content knowledge. They cannot avoid thinking to their own role as teacher and citizen. They have to take position in favour of emancipatory citizenship education if they consider science education as a socio-political commitment and not as a pre-packaged science that pupils have to swallow.

CONCLUSION

Of great interest to us were the identification of a citizen "portrait" that would be aimed through the new French curricula and the ways teachers consider their teaching as contributing to a citizenship education. This citizen's portrait of official curriculum creates a tension

between the dominant features of the "manufacturing" of a citizen who appears consistent with some form of docility and a "critical citizen" able to build his (her) own argued, rigorous point of view and to debate in order to make choice and responsible decisions for society.
According to data analysis of teachers' questionnaires, a minority of teacher aimed to a critical citizen education through the teaching of the "convergence themes" that can be linked with the SSI citizen emerging from literature: a citizen able to make reflective argued decisions to evaluate discourses of experts in order to debate in the public field.
This case study aimed at contributing to a deeper understanding of curriculum reforms in science education that internationally promote citizenship education Our work focused on a new approach with young pupils in French Middle Schools by "convergence themes" that may contribute to an understanding of how teachers negotiate with SSI in a context of a possible congruence with a critical citizenship education. The tension that emerged from our data analysis between a manufacturing of a docile citizen and an education of a critical citizen leads us to underline that it could be desirable to promote researches about this critical citizenship education considered by a perspective of the SSI research movement and also aimed by several teachers.

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THE PRE-SERVICE PHYSICS TEACHER AND THE CHALLENGE OF THE SOCIO-SCIENTIFIC ISSUES-BASED APPROACH

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Abstract: This article presents a study that investigated fourteen pre-service physics teachers. Starting with a partnership project between the university and five public high schools, two workgroups were formed to collectively develop didactic strategies seeking to introduce socio-scientific issues (SSI) in the classrooms of the partner high schools. The interviews with the pre-service teachers revealed that this project helped them become familiar with the theoretical framework (SSI), the school reality, and the experienced teachers' knowledge. Some difficulties in the implementation of the activities were identified, notably in relation to the lack of flexibility of school programs, the teachers' training, and the interdisciplinary nature of the SSI perspective. Regarding the applications of SSI in the classrooms, the data analyzed emphasized the role of these issues in catalyzing discussions that promote the exercise of argumentation by the students. However, they also revealed that the experienced teachers who introduced the activities seemed to have a tendency to prioritize actions in the classrooms that reinforced the development of arguments based on what is offered by various means of communication, raising the question of whether there was an actual contribution to the critical education of students, or merely an uncritical appropriation of a repertoire of arguments previously elaborated by journalists and/or specialists. These investigations are to be extended by means of a dialogue with frames of reference in the curriculum field, seeking new elements that help us understand the issues arising from this research.

Keywords: teacher training; science-technology-society; socio-scientific issues

INTRODUCTION

The way in which modern society presents itself is loaded with uncertainty and rapid change. Many changes are related to scientific and technological developments, which eventually interfere in the citizens' way of life, especially regarding ethical and moral values that cover the political, social, economic, environmental, and cultural spheres. The new millennium came bearing a series of challenges to be overcome by humankind, such as economic instabilities, climate change, AIDS, starvation, violence, terrorism, and international conflicts. This scenario places us in situations that require citizens who are well informed about global problems and prepared to play their role in society critically. This represents a great challenge to the school system and teachers, considering their function in the citizen development process.

According to Bernardo (2008), the Science-Technology-Society (STS) approach recommends the introduction of scientific contents in such a way that they could be articulated through socio-scientific issues (SSI). Science education based on the SSI approach has been considered one of the ways to introduce innovative actions into schools, based on discussions about controversial and socio-scientific topics that help students develop critical thinking skills.

However, diversity has been one of the features of this society that seems to resist any attempts to regulation. Even without significant actions promoted by youngsters against the status quo, the opposition to rules manifests itself, for instance, in the various behaviors that the different "tribes" display and that place them in radical opposition to any expectation of standardization.

In the context of education in Brazil, such conflicts are verified inside the classrooms. One of the most frequent complaints among teachers in the basic education system is related to the lack of interest by students, especially in scientific subjects—biology, physics, and chemistry. It does not mean this is their only complaint.

The first contact future teachers have with this situation involving schools and society takes place during their internship. It is usually a period marked by "reality check" (Lippe & Bastos, 2008), when the future teachers often watch practices that do not contribute much to promote the changes required by science education, and this can generate feelings of frustration and hopelessness.

According to Foerste (2005), one way of minimizing such difficulties would be to establish partnerships around collaborative projects between schools and the institutes responsible for training teachers in universities. Thus, future teachers (trainees), experienced schoolteachers, and university professors could interact to approach common interests, developing and implementing programs based on shared goals.

This study represents a subdivision of a larger project that focuses on training teachers to work according to the SSI perspective. Starting from partnership projects involving the university and five public high schools, two workgroups were formed to study the theoretical framework—STS and SSI—and to plan and implement SSI-based activities in the classrooms of the partner schools.

The initial training of the project participants and their relationship with the challenge of planning and implementing SSI activities in the classrooms were investigated. More specifically, the research questions were: *To what extent did the university-school partnership contribute to the initial training of the project participants? How did the future teachers experience the challenge that the approach via SSI represents?*

THEORETICAL FRAMEWORK

The discussion about the introduction of socio-scientific issues (SSI) in basic education has intensified in the last few decades, especially because of the situation of planetary emergency. Nevertheless, it is important to note that this matter is not new in the field of science education.

Viewed as a humanistic perspective to the science education (Aikenhead, 2008), the Science-Technology-Society (STS) approach has been recommended as an alternative to prepare citizens who are able to deal with SSI and controversial topics in a responsible way (Santos & Mortimer, 2009).

Despite the consensus points among those dedicated to interpreting how science education via STS would take place, the definition of the STS approach is still far from unanimous. What can be observed is a plurality of understandings, which can result from the complexity of the S–T–S relations and from the different notions of the theoreticians who interpret them. In this sense, many researchers took an interest in understanding the views outlined in some projects proposed until the 1990s. The studies carried out by Aikenhead (1994), for example, attempted to evaluate in quantitative and qualitative terms the presence of STS contents in relation to the presence of scientific contents usually included in traditional curricula. In both cases, a diversity of conceptions and approaches was identified, corroborating the multifaceted and eclectic nature of the STS approach.

A relevant aspect, which is almost consensual regarding STS projects, is the thematic character that guides the organization of the curriculum. Bernardo (2008) emphasizes the role of STS contextualization as a form of attributing meaning to scientific contents, through SSI that promote the articulation of several dimensions—scientific, technological, political, economic, social, environmental, ethical, moral, and cultural. This would favor an education that promotes the conscious exercise of a citizen's role when facing the challenges posed by modern life.

In relation to this subject, Santos & Mortimer (2009) suggest approaching topics that incorporate socio-scientific aspects to science classes, and claim that

> [...] from them, the teacher can develop a humanistic approach, exploring themes related to the students' experience that can arise in discussions and introducing issues related to values and attitudes. (Santos & Mortimer, 2009, p.215—our translation)

Many authors have sought to contribute to the definition of socio-scientific issues (SSI). Aikenhead (1994) emphasizes the problematic character these issues must include, functioning as "clusters" of sub-themes that are also problematic. Reis & Galvão (2009) and Levinson (2011, 2006) draw attention to the controversies that should characterize these issues, while Bernardo (2008) indicates the potential SSI ought to function as catalyzers of argumentative processes in the classroom.

This brief attempt to synthesize the topic does not consider the distinction some authors make between STS themes and SSI, as most of them do not find this discussion relevant. Nonetheless, the positions advocated by some authors, such as Zeidler et al. (2005), are worth mentioning. Attempting to separate the STS approach from the SSI-based approach, the authors use arguments based on the perception that aspects related to "moral principles and elements of virtue" do not concern the STS perspective and are the object of the SSI approach.

The introduction of SSI in schools has run into problems such as the lack of didactic materials compatible with this type of approach (Bernardo, 2008), inadequate teacher training (Sadler, 2011), and conflicts between the thematic organization of contents presented in the proposals and the programs structured over disciplines and traditional curricula. The latter happen in most schools and are the most recurring issue in our current concerns.

METHODOLOGY

The research presented here took place during 2009, 2010 and 2011. Aspects related to the implementation of didactic strategies aiming to include the SSI approach in high schools were investigated.

The activities were planned by two workgroups formed through partnerships between the university and five public schools in the city of Rio de Janeiro, Brazil. The groups were composed of one professor from the university, eight experienced teachers from the partner schools, and fourteen pre-service physics teachers working as interns under the supervision of those experienced teachers.

Beside the research goals themselves, the stages involving the planning and development of didactic materials can be identified with what Schön (1992) calls "reflective practicum," in the sense that they promoted the professional development of the experienced teachers from the partner schools as well as of the future teachers involved.

The didactic material used was produced and organized to introduce the following SSI in physics classes: "Production of Electric Energy by Means of Nuclear Plants," "Radiation in

Daily Life,” “Fuels to Move the World,” and “The Unlawful Occupation of Hills by Slums in Rio de Janeiro.”

All activities developed are strongly contextualized because they take the S–T–S relations into account, particularly the articulation among the political, economic, social, environmental, ethical, moral, and cultural dimensions promoted by each structuring theme. Each proposal involves studies on nuclear technology, radiological techniques, automotive and geotechnical technologies, and how they relate to society, which may help to catalyze the students’ reflections about the S–T–S relations. Regarding specific physical concepts, the themes explore knowledge from classical and contemporary physics in the areas of mechanics, hydrostatics, thermodynamics, electrodynamics, electromagnetism, radiation, and nuclear physics.

The activities were implemented in six classrooms, and the issues were introduced in the classes given by the experienced teachers as well as in those given by the future teachers, who always taught under the supervision of their experienced colleagues.

Apart from information about the training process involving the future teachers, this study tried to understand more subjective aspects specifically related to the implementation of these activities in the schools. These aspects included the function of the teacher, the role of the SSI approach, and the richness of the argumentative processes developed among the students in relation to the theme and the associated scientific concepts. The access to such information occurred through the perspective of the trainees and the experiences they had.

So, the research data were obtained through recorded semi-structured interviews with the future teachers and were guided by the following questions: (1) To what extent did taking part in this partnership project influence your training? (2) What aspects made it easier and/or more difficult to introduce the planned activities in the schools? The participants also commented on their impressions about introducing the SSI in the classrooms.

The interviews in Portuguese were transcribed, and the data were analyzed and categorized according to the interpretations derived from the interviews. All excerpts presented were translated by the author.

RESULTS AND DISCUSSION

The research subjects—the future teachers—will be identified, whenever necessary, as A, B … N in the presentation of the data.

The answers given to the first question were related to the categories organized as follows.

CATEGORIES	SUBJECTS													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Becoming familiar with experienced teachers’ knowledge		x	x		x	x		x	x			x	x	
Understanding of the school functioning	x	x	x		x	x	x			x	x			x
Opportunity to experience teamwork	x			x	x		x		x		x			
Knowledge about the theoretical framework-SSI	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Awareness of the S–T–S relations		x	x			x				x			x	

All the participants stressed the importance of the knowledge acquired with regard to the theoretical framework. Only five, however, demonstrated awareness of the S–T–S relations that the SSI can reveal.

Aspects related to the interdisciplinary nature of the proposals and to the teachers’ training were identified. Lack of time and the limitations imposed by school programs were mentioned. The following excerpt exemplifies some of the difficulties identified and emphasizes the crucial role of the teacher in the implementation of the planned activities, which can be related to the need for autonomy discussed by Bernardo (2008).

Participant C: "Before, I knew nothing about STS or about SSI. I think it was nice to work this way and to learn about these things […] now we have to face the addicted school structure [...] In our case, we worked in a partnership with the school [...] even though it was difficult because the principals always say that there is not enough time. I think that the stance taken by the teacher made the difference. He didn't back down. If he hadn't taken these risks, we wouldn't have been able to do this work."

Regarding the implementation of SSI in the classrooms, one of the interviews emphasized the role of these issues in catalyzing discussions that allow the exercise of argumentation by the students.

Participant B: "In my case the issue was radiation. I was afraid because it was a difficult classroom [...] I honestly never expected such a big change in their (the students) behavior. Suddenly everybody was discussing and trying hard to perform the activities I assigned them [...] I think that these issues help motivate the students to participate. And this was a difficult topic for them, because it was from the modern physics domain."

According to the participant in the following excerpt, it can be noted that the teachers seemed to have a tendency to prioritize actions involving the use of informative material rather than exploring the "scientific contents."

Participant F: "[...] there is a problem [...] the teacher couldn't make them (the students) speak scientifically. For instance, during the simulated jury, when the two groups discussed the advantages of alcohol over gasoline [...] one group mentioned that the source (sugar cane) is renewable and the other mentioned the disadvantage of having to prioritize sugar cane over other crops. The group said that sugar cane pollutes less than gasoline, but didn't justify this fact by comparing the burning processes involved. It's as if they were only repeating what was read […] without applying scientific knowledge. And the teacher also failed to encourage them to explore the whole process, as instructed by the SSI approach."

In the following excerpt, the participant demonstrates the extent to which the theme was able to drive the discussion, relying mostly on socio-environmental aspects, without failing to cover, albeit informally, elements concerning the technologies used in soil studies. Thus, the theme is identified as a discussion catalyzer, a feature that was indicated previously in the theme of radiation in daily life.

Participant M: "There was a moment in which their (the students') discussion in the classroom drew my attention. They were divided […] because the group was mixed […] there were people from all kinds of places: from slums and from residential areas. There were people in favor of occupying the hills and others against it. But, after a lot of discussion, they recognized the risks, the environmental problems, the urban impact […] and also recognized how the technology used to study the soil can help […] nevertheless, the need to have a house was the justification they used all the time."

In the following excerpt, a participant expresses empathy with the SSI-based approach, especially in relation to the theme studied. Besides, the trainee emphasizes the importance of the teacher's "courage" when confronting the *status quo*, represented by the school programs and reinforced by school culture. This may characterize one teacher's autonomous attitude. Therefore, again a participant valued the theme, involving nuclear plants, even if discussions about physics were absent.

Participant N: "What I think is that working with this theme was perfect. They (the students) loved to discuss the issue of plants in Japan because it was a very current topic […] but much depends on the courage of the teacher, because there are many difficulties with the school, the other teachers, the time frame, the program […] but they really enjoyed it. And so did I. It's a pity that they didn't explore the physics itself. They weren't even interested in explaining how a tsunami is formed. And we taught them that, but they didn't use it."

The following excerpt draws attention to the need for "complementary material" that ensures physics is learned. According to this subject's perspective and similarly to what has been presented in different contexts, the simulated debate did not lead to the acquisition of physics knowledge, because the arguments developed failed to involve the scientific knowledge related to the theme.

Participant J: "The complementary material is imperative. There must be exercise lists to reinforce knowledge about the Wheatstone Bridge, Pascal's Principle […] otherwise it seems that they (the students) don't learn any physics […] We were committed, during the creation of the activities, to making them talk about physics throughout the debate. But it's pointless […] they don't use physics to explain anything. It appears that they dodge this and explain things in the same way they did before the classes they had."

CONCLUSIONS AND IMPLICATIONS

According to the testimony of participants, working in partnership promoted an understanding of school reality and an opportunity to become familiar with experienced teachers' knowledge, the assumptions of the STS perspective and SSI-based approaches. Some difficulties regarding the implementation of the activities in the schools were identified, such as: school programs not likely to change, lack of time, teachers' training, and the need to work within an interdisciplinary perspective.

Some aspects presented here were identified in previous studies (Bernardo, 2008), especially in relation to strengthening professional identity and autonomy. These are crucial elements for teachers who intend to work using this approach in face of the challenges posed by school programs and the school culture in this case.

The comments indicate the role of SSI in catalyzing dialogue and argumentation. Nonetheless, a problem was observed by more than one of the participants regarding the incompleteness of the arguments developed by the students, which may be associated with a reductionist action by the teacher in relation to the potential of the issue to address associated scientific concepts and contents. This tendency of teachers to conduct activities in such a way that the arguments constructed by the students focus particularly on what is offered by various means of communication, was identified in previous studies (Bernardo, 2008). This could raise the question of whether the critical education of these students is actually being constructed on scientific foundations or if they are merely being offered a repertoire of arguments previously elaborated by journalists and/or specialists, conveyed mainly through the texts used in the classroom.

Of course there are still no certainties or answers regarding this issue. Perhaps we could start by pondering the difficulties involving the coexistence of ordinary language and scientific language, and how much more comfortable students can feel when basing their arguments on the former.

Another quite complex matter, which has been a challenge for us, relates to the fact that schools respond to the perspective represented by SSI with a great deal of confrontation. We have verified that other elements, for instance, pertaining to the political position of the teacher as a specialist in the subject or even the history of the development of school subjects and their constitution, have not yet been taken into account in discussions about the introduction of SSI in schools. To date, our studies have not identified, in the literature dedicated to such issues, a dialogue with the theoretical frameworks of the curriculum field or with the epistemology of the school subjects. Since we are dealing with a perspective that intends to promote a curricular intervention, it would be relevant to attempt to unveil research aspects that are more subjective and may bring about new contributions to the SSI research field.

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BRINGING MEANING TO SCIENTIFIC LITERACY BY MAKING TEACHERS VALUES EXPLICIT

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Abstract: This paper will consider the links between secondary school science teachers conception of scientific literacy, the values related to scientific literacy they hold and how this conception and the underpinning values affect their teaching practice. Six perceived expert science teachers who teach both at senior and middle school levels and across the range of science sub-disciplines (one senior biology, one senior chemistry and one senior physics) were involved in this project, three from Victoria and three from Queensland. Victoria and Queensland are two states of Australia, each with their own science curriculum and assessment practices. Of particular note are the different assessment practices of the two states during the final year of secondary schooling and the impact this has on the teacher's prioritisation of scientific literacy and the values related to it. All of the teachers were interviewed about their understanding of scientific literacy and how this influenced their teaching practice. The six teachers were video recorded teaching a middle school science class and a senior science class. The data were analysed to identify values that underpin their conceptions of science and science education. The analysis focused on the matching of the verbalised conceptions and values of teachers with their practice of teaching science Particular attention will be paid to the way the teachers interpreted the curriculum and the role of assessment based on their values. Data of the teachers from the two different states of Australia will be compared. This paper will report on these data.

Keywords: Scientific Literacy, Teachers values of science, assessment practices, interpretation of curriculum.

INTRODUCTION

This paper considers expert science teachers articulating their practice and their notions of scientific literacy and linking these with the values they promote in their classroom both through the articulation of their ideas and their realised practice. We use the term "expert" here in recognition of the fact that these science teachers are recognised by their peers as being skilled and forms of authority in substantial aspects of the teaching and learning of science. This paper will compare the data from the teachers from two different states of Australia.

An important part of the work of science teachers is to develop some understanding of what it means to promote scientific literacy with their students and to consider how this might look as part of their teaching. One way to achieve this is for teachers to become researchers of their own practice, with the support of science education academics, paying particular attention to the values of science they are promoting to their students. Such research involves teachers giving some thought to their notions of what scientific literacy is, what a scientifically literate person can do and how they can assist students to become scientifically literate citizens. Teachers consider their notions of scientific literacy in terms of what it is they believe is important for students to be able to know and do with science. These considerations in turn lead teachers to identify the values of science that they hold and promote when they are teaching science.

Values, Attitudes and Beliefs

Values, attitudes and beliefs are central to the teaching and learning process. Halstead (1996) succinctly defines as the principles, fundamental convictions, ideas, standards or life stances which act as general guides to behaviour or as points of reference in decision making or the evaluation of beliefs or actions and which are closely connected to personal integrity and personal identity" (p. 5). However the terms values, attitudes and beliefs are often used synonymously. Hanselman (1979) has differentiated between values and attitudes. "Attitudes are enduring systems of positive and negative evaluations, emotional feelings, and pro or con action tendencies with respect to social objects. Values grow out of attitudes; they are what determine how a person is going to use his life" (p. 4).

Beliefs, while being a term often used to describe both attitudes and values, can also be differentiated from these terms, although at times this can be problematic as the range of definitions provided for belief varies significantly (see Jones and Carter, 2007, p. 1069 for a brief summary). However, Fishbein and Ajzen's (1980) differentiation between attitudes as affective constructs and beliefs as cognitive constructs is generally accepted. Seah (2002) also attempted to distinguish 'value' from 'belief' in the following ways:

- A belief is about the degree to which something is true while a value is the degree to which something is important
- A belief exists in a context while a value exists in the absence of any context.

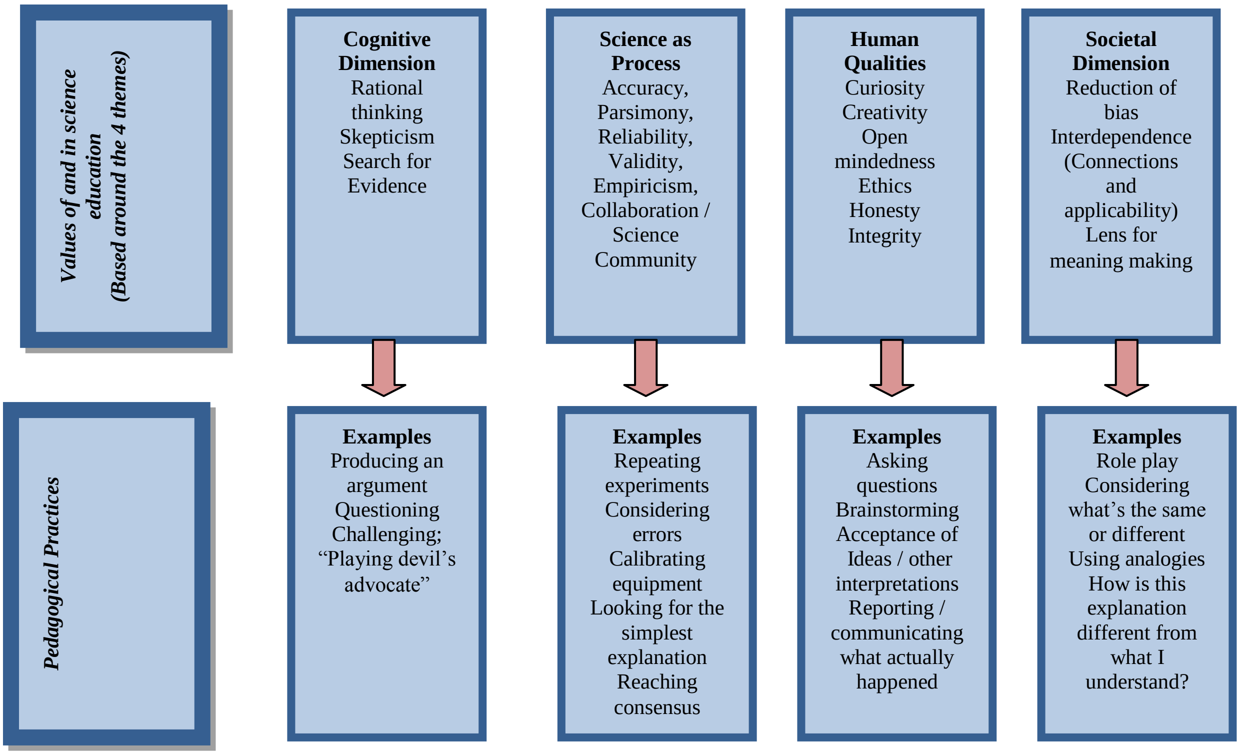
In summary, it appears that both beliefs and attitudes may be context specific, while values are not. Values and beliefs both have a cognitive dimension associated to them, while values and attitudes appear to be developed within an affective domain. What does appear apparent is the notion that values do play a large role in how our attitudes and beliefs are formed.

Values in Science Education

Values in science education include the epistemic values of science (the values of science itself), societal values and the personal values of scientists. There does not seem to be much agreement about what these particular values should be in science education across all three values types. For example, Western science has different values from other indigenous science value sets. Using the work of Corrigan & Gunstone (2007), who explored values of science under four broad themes: science as a process; human qualities; cognitive dimensions; and societal dimensions and Siddique (2008) who explored some manifestations of a number of these science values, the authors grouped the values into four groups. Figure 1, shows how these values of science may manifest in teachers' practice.

While some of the values in this framework may be open to debate and contestation (such as, is objectivity really a value or should it be something more akin to reducing bias as scientists are human and bring their own biases to their work), this framework, in linking the values with possible manifestations in the science classroom, does provide some useful insights into the often implicit teaching of science values. In this study, the manifestations were used to identify teaching practices that indicated a teacher's values; either through the teachers actions or their words. How such values relate to scientific literacy is also an important consideration.

Figure 1: Conceptual framework for the manifestation of values of science in teachers' practice



Scientific literacy – an education imperative

Another dimension to the work of science teachers is their response to the national (and international) imperative to produce scientifically literate students. Scientific literacy is associated with other forms of literacy, such as reading and mathematical literacy (OECD, 2006). However, scientific literacy also needs to account for how science knowledge is represented and communicated to students so that they can engage with science in their life.

No consensus exists for universal acceptance regarding the conceptions of scientific literacy (Osborne, 2007; Roberts, 2007), and this may be due to the dependence of scientific literacy on context. However, science education researchers agree that students must have some science content knowledge to be scientifically literate (e.g., Millar, 1996; OECD, 2006; Osborne, 2007). Roberts (2007) in his review of scientific literacy/Science literacy proposes a model to encapsulate much of the thinking in this area over the last 50 years. Roberts proposes that there is two predominate Visions of Scientific Literacy aligned at opposite ends of a continuum. Vision I derives it's meaning from within science and focuses on the products and processes of science itself. Vision II derives its meaning from the character of situations with a scientific component, or those situations that students are likely to encounter as citizens. Vision I is scientist- centred, while Vision II is student-centred.

For students, choosing a science education that is of the Vision 1 type or Vision I-II type (as there exist very few examples of Vision II type science education), means a choice for science education that has consistently led to decreased interest and lower enrolments in school science. This is largely due to Vision I with its emphasis on traditional canonical science, as opposed to Vision II, which "seeks to enhance students' capacities to function as life-long responsible, savvy participants in the everyday lives; lives increasingly influenced by science and technology" (Aikenhead, 2008, p.1). As Aikenhead points out:

> When conventional, academic, decontextualized science (a Vision 1 view of scientific literacy) changes to a contextualized science (Vision I-II view of scientific literacy in practice), the context **and content** are mostly dictated by students' everyday worlds, rather than by scientists', teachers', or curriculum developers' ideas of appropriate contexts and content for school science. Changing the meaning of "science" in the domain of school science takes us beyond policy and practice (p. 2).

Additionally, Millar (1996) suggests that this content knowledge of scientific literacy is important for both intrinsic and instrumental justifications. Intrinsic justification refers to cultural aspects, i.e., scientific knowledge can help people to satisfy their curiosity about the natural world, which is also very important in learning. Instrumental justification, on the other hand, refers to the utilitarian aspects, i.e., scientific knowledge is necessary as a foundation for making informed practical decisions about everyday matters, participating in decision-making to science-related issues; and working in science and technology related jobs (Millar, 1996, p. 9). Both of these justifications are consistent with science content applied in context, because this content may provide learners with the knowledge required in socio-scientific decision-making and may satisfy their curiosity about the natural world around them.

Aikenhead's statement and Millar's research have significant ramifications for the practice of science teachers, many of whom have grown up as learners and then teachers with a Vision I dominated science education experience. For them there needs to be a significant cultural shift in how they view science in the their classrooms that will educate their students to become more aligned with a Vision I-II or even possibly a Vision II type view of scientific literacy. Implementing such teacher change is at the heart of this project through the process of teacher research focused around professional learning.

METHOD

Our research identified, through peer recognition, six 'expert' science teachers, with whom we explored their conceptions of scientific literacy in their classroom, what values underpinned their conceptions and how this matched their teaching practice. The six teachers work in secondary schools in Victoria and Queensland, Australia and teach both senior secondary (biology, chemistry and physics) and lower secondary science classes.

Initial exploration of their conceptions and values was conducted via a semi-structured interview. This allowed the teachers to speak openly about their teaching experiences and to expand their thinking throughout the interview thus, the direction that the interviews took was determined by the researchers and the teacher as the interview progressed. This approach provided rich, detailed stories about the teachers' practice that when analysed, allowed us to identify examples of the values underpinning their teaching practice. The six teachers were filmed teaching two lessons each; one senior class and one class of year 7 – 10 science (13-16 years of age). These videos again provided rich examples of their practice in action.
The next steps in the research project included providing these teachers with an opportunity for exploring their own practices during a second semi-structured interview. Teachers were able to use both their interview and video data to comment on the manifestation of values and their notions of scientific literacy as they saw them in their practice. Finally, teachers were asked to plan a lesson that would portray one specific value to their students.

RESULTS – Values manifesting in Teaching Practice

The following is a table of excerpts from a unit of work that was written by one of the participants, Greg (pseudonym). While the participants were only asked to plan one lesson based on a value that they wished to promote, Greg found that values related well to an entire unit he was teaching on diseases and so he highlighted the values he was promoting each lesson.

Values	**Lesson description**	**Further explanation from interview**
Cognitive Dimension- *Skepticism*	Lesson 2 – 4: Movie – *what do you believe?* Watch a popular movie (I am legend / outbreak etc) and ask students to construct a list of fictional and factual references to infectious diseases throughout the movie. *Pedagogical practice*- generating what is not reasonable- fictional as opposed to factual	"But with Skepticism, we watch a movie, either *I am Legend* or *Outbreak* or *Infectious Disease*, and then they ask...yeah *Outbreak* is great. And then I actually get kids...so Skepticism, they construct a list of fictional and factual references they use in the movie... ...like that, and then they have to...whatever is fictional they write down, say why it was fictional and then turn it around to make it factual."
Cognitive Dimension – *Rational thinking*	Lesson 5: Students *Pedagogical practice*- "myth bust" the movie **using research and logic to improve the scientific credibility** for the movie producer / director. This culminates in the students writing a letter to the movie producer / director suggesting corrections for the scientific inaccuracies.	"So they came in with their...the Rationality one...so after the movie I got the kids to write a letter to the director or producer saying, "You need to change this to fix the movie."
Societal Dimension Interdependence	Lesson 9: Pedagogical practice- applying what you know and making decisions Investigation topic: global warming and the spread of disease are there links?	"Ah yeah, so Interdependence...I had just an investigation topic. Sometimes I just throw this in, with nature and science and human beings and interactions in nature. I sometimes do that if the kids are an advanced group. I try and get them to write what's the link between global warming and the spread of diseases, like sort of what the humans do and stuff like that."
Human Qualities - Creativity	Lesson 10: Pedagogical practice- Make your own disease Students design own disease in a group. They should consider: Transmission, symptoms, mortality, treatment / control, creative microscopic drawing and name of disease. Students are to present their disease to the class (gallery walk). This could be viewed as valuing science community.	"And then Creativity—I get the kids to design their own disease. So they get a piece of paper. It's like a Venn diagram but sort of a little bit different. They've got to say the transmission, symptoms, mortality, treatment, and they have to draw it microscopically. Like say if it's a bacteria, like what type of bacterial shape it is. And then you put them around the class, and they do a gallery walk so they look at all the other diseases."

Greg, along with the other two teachers who teach in Queensland, had a great deal of connectivity between the values he espoused and his pedagogical practices, regardless of the level of secondary education. Greg actually did what he said he was going to do and therefore was able to teach in ways that promoted specific values and his notions of scientific literacy with his students. The Queensland education system allows teachers a greater ability to embed their assessment practices far more fluidly within their pedagogical practices and therefore create more opportunities for informal assessment during their classes, regardless of the year level.

The Impact of Assessment

Mark (Victoria) Mark's shift in emphasis from teaching in an open and exploratory style (in years 7 -11) to teaching with a major focus on content in year 12, is emphasized in the following excerpt.

> "…you're right that content is a killer. I succumbed to it [the content] even though it's not the way I would necessarily like to teach a Year 12 year. But I've always felt, that we're doing that [working with the content] now, and I've been fortunate that I've been able to introduce another subject in Year 10 called creative science, where I do exactly what you've just explained [work in a more exploratory and open style].... and I guess for me the key here is to develop that in the Year 10 and Year 11 classes so that in Year 12 it is already part of their thinking. And then I feel that there is an opportunity to be able to do what I like to do in Year 12 given the rigors of Year 12 and the situation." (Mark, 2nd interview)

Mark's comment is indicative of those from the other two Victorian teachers, who all felt that unless they were preparing their year 12 students for the exam, then they were not doing the right thing by their students.

Larry (Queensland) Larry's consistent focus on making links between content and meaningful contexts, a feature of all the Queensland teachers comments, was irrespective of what year level being taught.

> "It's definitely about making links and I think they're….I don't know why, they don't seem to be able to see a connection between doing changing colours in a test tube and what's happening down in the creek." (Larry, 2nd interview)

CONCLUSIONS AND IMPLICATIONS

From our research it has apparent that teachers read and interpret curriculum in ways that match their value set, which in turn influences their notion of scientific literacy and the way they present science to their students. We were able to identify this through both interview data and the video footage of their teaching practice. A related factor was the impact of the assessment practices, as defined by each state of Australia, that teachers are expected to follow. Our research found that e during the final year of secondary school, a perceived higher stakes environment, teachers felt greater compulsion to teach in ways that met students' perceived needs. Their teaching practice shifts in focus to preparing students for the final assessment, rather than what the teachers feel is important for students to understand at the end of their secondary school science education.

Scientific literacy as an integral part of science education has been identified in this research as linked to teachers' values. Additionally, we have identified links between teachers' values, their interpretation of curriculum, teaching practices and assessment practices (especially at the senior level.) Teachers' values of science appear to be central here. A valuable professional learning experience is found in teachers making explicit their values of science education to generate meaning around scientific literacy and make more informed decisions about how scientific literacy can be promoted in their classroom.

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STUDENTS' OPINIONS ABOUT A SSI: PERSPECTIVES REFERED IN THEIR ARGUMENTS ABOUT BEARS' REINTRODUCTION

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Abstract: The use of Socio-scientific Issues in Science classes is proposed to define the curriculum's organization and design activities with the aim of encouraging students to develop scientific literacy. In this research, an activity of bears reintroduction in the Pyrenees has been designed and developed in order to analyze from which perspectives do 125 students from two secondary schools (aged 13-14) placed in Barcelona make their arguments to base their decisions about the reintroduction. Data was collected with an open-ended questionnaire included in the activity designed and the results show that students justify their opinions with different kind of arguments from different perspectives as social-oriented, ecological-oriented and moral-oriented. However, they used to use only one argument in their justifications so they show difficulties to consider the different perspectives that are related to a socio-scientific issue when they have to make a decision.

Keywords: Socio-scientific Issue, Decision making, Nature of Science, Secondary school, Bear reintroduction

INTRODUCTION

Background and rationale

Scientific literacy has become an internationally well-recognized contemporary educational goal (Nuangchalerm, 2010). Although the definition of scientific literacy is controversial, students' ability to deal with Socio-scientific Issues thoughtfully has been recognized as one of the important components of scientific literacy (Sadler, 2004). During the recent past, Socio-scientific Issues have been introduced in science classrooms and have been investigated by science education researchers (Albe, 2007).

The notion "Socio-scientific Issue" (SSI) has been proposed as a way of describing social dilemmas impinging on scientific fields (Kolsto, 2001; Sadler, 2004; Zeidler et al, 2002). In general, dealing with a SSI often involves argumentation and decision making on this issue as these are typically open-ended and ill-structured problems which citizens will find in their lives. This type of decision-making process needs to be studied in science education (Albe, 2007) and it becomes important to know how students take decisions in these contexts and how do they evaluate contradictory scientific information. Some authors considered that students are led to emphasize personal experiences or values (Sadler et al, 2004), others underlined that the overriding considerations are social or epistemological (Ryder, 2002) and some authors have questioned the importance of using scientific knowledge when SSI have to be settled.

Objective of the research

Giving the theoretical framework just presented, the specific objective this research addressed was analyze from which perspectives do students make their arguments to base their decisions about the bear reintroduction. In this study, in using the term "perspectives", we are referring to the type of information (for example, as preference for either scientific or social information) participants used in the arguments generated in a decision-making process.

METHODOLOGY

Data collection

Research population

In order to achieve the objective just presented, an activity related to a SSI was designed and carried out in two secondary schools in Catalonia (Spain) in a science class in the context of formal education. Both schools are situated in towns near Barcelona but students from school 1 come from a low social and economic bracket, with 65% of them being immigrants mainly from South America and The Maghreb while students from school 2 come from a medium to high and cultural bracket, with 10% of them being immigrants. A total of 125 students (66 male and 59 female, aged 13 to 14) took part in this study.

SSI classroom activity design

The first phase of the research consisted of designing the classroom activity and the open-ended questionnaire we would develop and use to collect research data. After knowing which students would participate, we select with their science teachers which SSI would be the most suitable, positing the premise that incorporating these issues in science classrooms has to be related to scientific knowledge studied (Barab et al, 2006). As a consequence, it has to be an issue related to what students had studied in previous lessons and to scientific contents and competences defined by Spanish curricula. Considering these requirements, ecology bloc was selected as one of the most suitable subject for carrying out our activity and, as the United Nations declared 2010 to be the International Year of Biodiversity, bears' reintroduction in the Pyrenees was considered the most adequate subject for carrying out our activity.

In 1996 bear reintroduction in French Pyrenees began with the support of Live Program of the European Union and Catalonian Government although there were different groups against this initiative. Since then, it became a local controversial. As with all SSI, politics, economics and cultural aspects play an important role in decision making about bear's reintroduction in the Pyrenees. This issue is a social dilemma impinging scientific fields because people have to decide if this initiative continues and more bears are reintroduced in this territory where bear disappeared as a result of hunting. Since this initiative was proposed, there have been different stakeholders that have opposed to and it is an issue that usually appears in the media. Although the students who participate in this study did not live in Pyrenees, researchers thought that it was important talk with them about this reintroduction because they probably will have to face with species reintroductions in the future and make decisions about them as citizens.

Once the classroom activity and the open-ended questionnaire have been designed, they were presented to an expert group composed by teachers and science education researchers who analyzed them and made suggestions which were then incorporated. In the second phase these instruments were applied.

The activity designed lasted 2h and was carried out on February 2009. It was divided in two sessions. At the first one, students read news about bears' reintroduction and the controversy related to it in order to being introduced to it. When students already knew this information, they discussed in pairs about the different viewpoints supported by all the stakeholders implied in this issue (as politicians, scientists, hunters, farmers or environment organizations for example). After discussing this information with the whole class, students read and discussed scientific information about bears' and its ecological requirements taking into account students should use these concepts in their decision making. Then, students were asked to respond individually to the following open-ended questions and wrote down their answers:

- *Do you think that bear reintroduction should be done in other place where people would not be hurt by bears? (Justify your opinion).*
- *Do you think that now we can't know what consequences will have bear reintroduction so we need do more researches in the field? (Justify your opinion).*
- *How do you explain that scientists have not achieved an agreement about the bear reintroduction? Justify your opinion and explain how do you think it could be reached*

In the second session students had to write an argumentative text presenting their personal opinion about bears' reintroduction after following a guide and discussing it in groups before explaining what they have learned in this lesson and which changes would propose in order to improve the classroom activity development.

Data analysis

According to other similar studies and to our research aims, qualitative methods combined with quantitative parameters of analyses were employed. The first phase of the analysis consisted of categories definition following an inductive-deductive method. As a first step of inductive analysis of the data (Lincoln & Guba,1985), questionnaires responses were read in order to make preliminary notes regarding patterns emerging from data. As a second step, the emergent categories were compared with the categories obtained in other studies and then they were used to classify the arguments given by the students in their responses. The second phase of the analysis was analyzing the frequency of the categories considering qualitative indicators and quantitative measures described in Wu and Tsai (2007) as will be explain in the next point. All this process was made by an independent examination of data done by investigators and the support of Atlas.Ti.

RESULTS AND DISCUSSION

In answer to the question *"Do you think that bear reintroduction should be done in other place where people would not be hurt by bears? Justify your opinions"*, students justify their opinions generating arguments from different perspectives. After categories definition following an inductive-deductive method, in this study, as is shown in table 1, learners generated their arguments from different perspectives such as "social-oriented", "ecological-oriented", and "moral-oriented" perspectives.

Category	Key words	Exemplar	% students refer to
"Social-oriented" arguments	Welfare or safety		67%
Focus on human	Human's welfare or safety, economic aspects	*"In my opinion bears should be out of the Pyrenees to prevent the bears will eat sheeps"* *"Bears should be in another place because if they are in the Pyrenees, people will be afraid of them"*	36,8%
Focus on bears	Bears' anthropomorphism, bears' welfare or safety	*"Bears should be in another place because if they continue in the Pyrenees, they will be afraid of people"* *"I think bears will be better in other place because they will be safer and live quietly"*	30,2%
"Ecological-oriented" arguments	Habitats, extinction, ecosystems, food chains,	*"I think bears should continue in the Pyrenees because it's their habitat"* *"Bears' reintroduction should continue to avoid its extinction"*	12,3%
"Moral-oriented" arguments	Right to live, behaviors or beliefs considered to be good or bad	"*I think that bears should be in other zone because if they hurt people they have to be punished"* *"Politicians should take into account that all species have rights and Earth is our planet"*	20,7%

"Table 1. Categories and frequency of perspectives from which students make their arguments to base their decisions about bears' reintroduction"

Social-oriented arguments were based on the welfare of society or human sympathy and an example is *"In my opinion bears should be out of the Pyrenees to prevent the bears will eat sheeps"*. It is important to note that, in the analysis, authors considered that it was important to point out that there were students who referred to anthropomorphisms talking about bears as if they were people and, in their arguments, refer to bears' welfare. An example of these kinds of arguments was *"Bears should be in a territory where they can't be afraid and live safety"*. On the other hand, there were students who justified their opinions with the same arguments but pointing their point of view on humans: *"I think bears should be in a territory where people can't be afraid by them"*. As a result of this fact, authors distinguished two subcategories in the "social-oriented" category depending on whether students focused on talking about humans' or bears' welfare.

In contrast, ecological-oriented arguments referred to the interactions established between species and the environment where they live as it can be seen in this example *"I think bears should continue in the Pyrenees because it's their habitat".* It has to be considered that successful biological conservation management programmes like reintroductions also depend on an understanding of the biology of the organisms concerned, and how they interact with their surrounding environment (Grace & Ratcliffe, 2002).

Finally, moral-oriented arguments were related to attitudes, facts, behaviors or thoughts that were considered good or bad, for example *"I think that bears should be in other zone because if they hurt people they have to be punished"*.

These results were consistent with Wu and Tsai (2007) analysis because in their framework they determinate that in a SSI, learners may generate their arguments from different perspectives such as social, ecological, scientific or technological. Nevertheless, there were some differences that we would explain. In our study, economic-oriented arguments were included in social-oriented perspective because authors considered that economic safety is part of society welfare's. On the other hand, science-oriented arguments were represented by ecological-oriented while technology-oriented arguments were not represented because students didn't identify a technological component in this SSI. It is important to note that, although moral-oriented arguments were not distinguished in Wu & Tsai study, moral perspective is recognized in other studies like Fensham (2002) and Albe (2007). As SSI are of a contentious nature, they may be analyzed according to different perspectives, they do not lead to simple conclusions and often they involve a moral or ethical dimension (Sadler, Chambers, & Zeidler, 2004).

Another interesting aspect is to analyze how many arguments are provided by learners. In this research, students utilized, on average, only one argument to justify their opinion (mean = 1,27) although there are different perspectives related to this SSI. These results do not concur with results obtained in Sadler, Chambers, and Zeidler (2004) and Yang and Anderson (2003) where learners were oriented to reason from multiple perspectives. Despite this difference, in this research, students who justify with more than one argument use to base them on different kind of perspectives and ecological-oriented considerations where the less proposed as occurred in the studies cited above. This trend might be due to their insufficient abilities to make the connections between what they had learned in science classrooms and the SSI they encountered in daily life (Wu & Tsai, 2007). Contrary, Kolsto (2001) argued that students' knowledge acquired in science classroom can serve as tools for their informal reasoning and decision-making on controversial issues.

CONCLUSIONS AND IMPLICATIONS

In the present research, students generate their arguments on bears' reintroduction from different perspectives as social-oriented, ecological-oriented and moral-oriented. Despite this fact, the results of this study suggest that students have difficulties to consider all these different perspectives related to a SSI when they have to make a decision, so, it is suggested that they are not able to reason from multiple perspectives. Moreover, ecological-oriented arguments were the less use although students have studied ecology before doing this activity. As a result, this study shows that students also have difficulties to use scientific knowledge when they make a SSI decision.

Taking this into account, it would be important to carry out activities to promote the analysis of the controversy from different viewpoints and to facilitate the scientific knowledge transfer to SSI decisions. To example this idea, in our classroom activity development we would design a set of new exercises in order to emphasize the science and values that each stakeholder implied in bears' reintroduction draw upon to justify their ideas while students understand they will need to know these information to be able to justify their opinions. On the other hand, the instructor could also explain the relationship between the SSI and the concepts covered in class or share their viewpoints as long as they explain how they use facts to come up with their view or resolution.

In conclusion, further research will be needed in order to improve our understanding of decision-making related to SSI. In particular, some studies can be conducted to examine deeply how students make decisions in these contexts and describing which teaching strategies could be used to enhance students' learnings transfer and engaging them in scientific practices in order to help them understand the nature of scientific knowledge.

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MIMICKING AUTHENTIC SOCIETAL PRACTICES FOR LEARNING ABOUT THE USE OF SCIENCE-RELATED INFORMATION

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Abstract: Modern standards for science education ask for promoting scientific literacy for all students. One of the central objectives is that all students should develop skills to be able to actively participate in societal debate on applications from science and technology. One of the central prerequisites for participating in societal debates is the competence of doing evaluations. But, evaluation competence covers several different dimensions: evaluations in science, evaluation about science, or reflecting evaluations done by others. This essay discusses using the socio-critical and problem-oriented approach to science teaching as a basis for learning about evaluation processes with regard to societal questions of science and technology. The idea of filtered information will be introduced for better understanding the process of evaluations done by different groups of persons in society. Learning about filtered information is operated by mimicking authentic societal practices in which science-related information is filtered and used. Examples and experiences from lower secondary science classrooms are reported.

Keywords: science education, curriculum development, scientific literacy, socio-scientific issues, filtered information

LEARNING ABOUT EVALUATIONS IN SOCIETAL-ORIENTED SCIENCE EDUCATION

A central objective of developed scientific literacy (Bybee, 1997) is to become able to understand and to participate in societal debate concerning questions of science and technology (Roth & Lee, 2004). Although the goal is not new and respective standards are now available for quite a long time (e.g. AAAS, 1993; NRC, 1996) the practice of science teaching in many countries is still neglecting the societal dimension of science education and the promotion of respective skills for active participation in society (Hofstein, Eilks & Bybee., 2011).

In the core of the skills to take up own interests in society and to participate in societal debate is the competence of doing evaluations (KMK, 2004). In contrast to other areas of science education, the competency of doing evaluations has typically not been taken into account very seriously in many traditional science curricula (Marks & Eilks, 2009). This observation becomes even truer when we understand the area of evaluation not just as evaluating *in* science (in other words, evaluating the processes of knowledge discovery, measurements and learning results), but rather as communication and evaluation *about* science (an evaluation of the role of science in technical, economical or societal developments).

Need for change towards more societal-oriented science education and a more through focus on learning to do evaluations gains growing support from different theoretical resources. In the German-speaking realm, this view coincides with the concept of *Allgemeinbildung* (e.g. Elmose & Roth, 2005), defined as the educational upbringing of pupils to be responsible citizens characterized by the abilities of self-determination, participation, and solidarity in a democratic society (Klafki, 2000). This view is also in accord with an understanding of scientific literacy as being multidimensional (Bybee, 1997) or rethinking traditional science education from purely "*Science through Education*" approach, in order to adapt science lesdsons into a program of "*Education through Science*" (Holbrook & Rannikmae, 2007).

As said above, examples and justifications for a more thorough orientation of science education towards its societal embeddedness are not new (Hofstein et al., 2011). Today many of these approaches are subsumed under the headline of socio-scientific issues based science education (Sadler, 2004). The most prominent example of this orientation of science education in German-speaking countries is the socio-critical and problem-oriented approach to chemistry and science teaching by Marks and Eilks (2009). Such lessons demand that authentic societal controversies be investigated in science classes. These controversies provide not just a chance to learn the subject matter-based aspects of the topics in a motivating situation, but also to uncover opportunities for pupils to directly interact and deal with such conflicts, including how to personally take part in them.

THE IDEA OF FILTERED INFORMATION

Within every science syllabus the learning of science subject matter knowledge is described. Also we find in almost all curricula objectives focusing the nature or science, e.g. to learning about processes of scientific knowledge generation or understanding the nature of scientific models. The students should learn to evaluate and reflect the potential of science and scientific information to solve problems and how reliable and secure scientific knowledge is. The students should learn to be able to estimate and evaluate scientific discoveries and information, especially with respect to the principally temporary character of such knowledge and theories.

Without wishing to devalue this viewpoint or drive it out of the science classroom, we do believe, however, that we should somewhat relativize - or at the least expand - this way of thinking. We need to be conscious of the fact that only the tiniest fraction of our pupils in mandatory school science classes will ever come into contact with authentic science and/or emerge with the capability of evaluating such things. We should be aware that most scientific information the vast majority of our students will come into contact with is not from resources from within the community of scientists. Such 'scientific' knowledge can be found in scientific journals, conferences, or academic books of science. Access to such knowledge, despite populist representations of science, is limited to scientists. Only scientists have access to the original scientific literature and only sufficiently educated scientists are able to understand the texts and presentations in question.

As soon as we start to examine populist literature forms or school textbooks and teaching aids, we are no longer dealing with original scientific information. Contact to authentic scientific information is not even extant in everyday situations and societal decision-making bodies, which occupy themselves with subject matter-based inquiries into scientific and technical issues. The information presented has not even been drawn from the original sources of information. Sometimes it is not even prepared by scientists with qualifications in the area in question. Nevertheless, everyone – also the non-scientists - will come into contact with scientific information. We can be certain that all of our pupils will be confronted with such scientific information presented in not-authentic scientific form in their future lives, whether the source is TV, newspapers, brochures, or advertisings. Access to scientific information via this way is prepared by special interest groups, politicians, journalists or advertisers.

The way of information from science towards us is long. Every time the original information is processed by individual groups from the above mentioned professions, filtering takes place. Each step is carried out by a person, be it a scientific journalist, news agent, regular journalist, author, editor, etc. The final product is hugely influenced by the individual foreknowledge, interests, motivation and subject matter and linguistic competencies of the writer, and also each person being involved along the filtering process. This is the same as in the children's game "silent mail", where a message is whispered from person to person down a long line, then checked for accuracy at the end: a process which hardly ever succeeds. The further we move towards everyday life, in this case towards the press media confronting us in our every lives (newspapers, magazines, radio and television), the more the information most probably is filtered and altered. The further one travels from the domain of science, the greater the chance that the filtering persons do not possess the subject matter knowledge necessary for the task at hand. E.g., we can be fairly certain that the average editor in a local newspaper responsible for creating news stories did not pursue science studies intensely and actively after his or her formal science education in school was over.

Thus, contact with scientific information in everyday settings may not just be a simple evaluation of the pertinent knowledge. Frequently, it is just as – if not more - important to understand which pathway the transmission of information followed and exactly which interests have played a role in the transportation of this knowledge. Widely different people have played a part in the process. It goes without saying that such groups as lobbyists, special interest groups, advertisers and politicians have and are following their own agendas. Yet journalists also possess interests, even if they are as relatively clear as the wish to bring an attractive journalistic product to market, one which is offered with an eye towards potential customers by specifically selecting and preparing information for the target group in an interesting fashion. It has already been mentioned that the subject matter qualifications of the author are most often not clearly recognizable. But the filtering process is by no means determined solely by the knowledge-based professional competence of the author. Of equal importance are such factors as personal interests and the competency to represent and pass on information in a solid, understandable and objective manner (or at the least to intentionally and self-consciously craft such representations in a fashion which mirrors reality as closely as possible). In this regard, a double-filter mechanism can be recognized (Figure 1).

Figure 1: The doubled filtering process of scientific information

These filtering processes can quite possibly exert more influence over the individual than the information itself. Understanding this filtration is directly related to understanding how to (re)act towards such information. This is true, for example, in the case of determining the credibility of an information source. Learners must develop mechanisms for evaluating such things. This includes working out various strategies like self-consciously contrasting different pieces of information quite possibly stemming from sources with diametrically opposed viewpoints, in order to finally classify the information presented by all of the sources. But the question of exactly how such filtering takes place and how we are to deal with such an event is of critical importance for even approaching such information. Yet most science instruction barely even broaches this issue let alone makes it into an element of overall teaching goals or methods.

MIMICKING AUTHENTIC SOCIETAL PRACTICES OF INFORMATION FILTERING IN SCIENCE EDUCATION

The socio-critical and problem-oriented approach to chemistry and science lessons (Marks & Eilks 2009) aims especially at the development of interdisciplinary communication and evaluation competencies. It does this in addition to attempting to increase levels of student motivation and the perception of relevance by constructing meaningful connections between basic subject knowledge and learning. These units start by selecting authentic societal controversies. They are structured using authentic media and consciously choose to employ two methods: attesting one's opinion and debate. In order to learn about societal discourses, methodology is selected, which contrasts the various opinions found in the public forum (Figure 2).

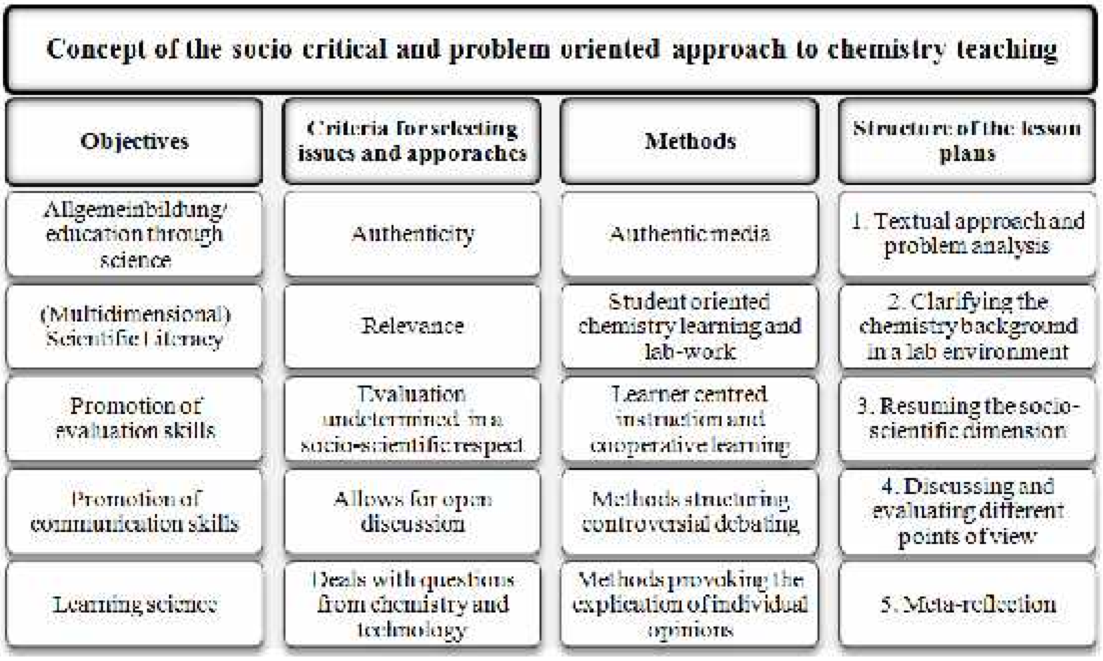

Figure 2. Model of the socially-critical, problem-oriented approach to chemistry teaching (Marks & Eilks, 2009)

Contrasting of various opinions (Figure 2, column 4) is methodologically achieved by mimicking authentic societal practices which either transport this type of information within society, carry out debates, or make decisions about such controversies. A commonly known possibility is offered by role-playing exercises (e.g. Marks, Bertram & Eilks, 2008) in which various opinions are represented and societal discourse is imitated. However, the potential yield of role-playing and planning games has often been criticized. The necessary preparation is very time-intensive and pupils' competency in debate and argumentation techniques is often not up to the task. Especially younger, unpracticed students cannot present their arguments in an eloquent manner and carry out their reasoning in a somewhat helter-skelter, non-integrated fashion. This is especially the case when a topic has only an indirect linkage to their everyday lives. When this occurs, the role which the learners are required to act out remains unfamiliar.

Students have difficulties with the complexity of the role, because they do not possess the necessary, accompanying background experience. Because of this, the role-players cannot react flexibly enough and tend to stick to a "script" with regard to their assigned position. But role-playing exercises are generally quite successful whenever the learners bring a large amount of personal experience with them. This was our experience for a teaching unit based on dieting (Marks, Bertram & Eilks, 2008), since our pupils already understood the TV talk show format and had already done a lot of personal thinking about the topic beforehand. Abstract topics like climate change, however, tend to make this process noticeably more difficult (Feierabend & Eilks, 2010). Pupils do not possess extensive personal links to the topic, even if it is frequently discussed in the media.

Due to this factor, we classify methods with clearer structures as those having higher potential. This is true whenever we actively begin categorizing the broad spectrum of available teaching examples (see Table 1). We have increasingly developed such methods within the socio-critical and problem-oriented approach to science lessons. Development of all the methods was inspired through processes of mimicking the work of such people doing the filtering and evaluation processes, like journalists, consumer product testers or advertising specialists. Table 1 gives an overview of previously documented teaching units and potential scenarios.

Place/filter medium	Imitation of societal practice	Example
Open discussions	Role-playing of a TV talk show or podium discussion	Debate about diets (Marks, Bertram & Eilks, 2008)
Announcements from interest groups	Analysis of brochures and podium discussions	Biodiesel (Eilks, 2002)
Political hearings and committees	Committee of experts planning game	Climate change (Feierabend & Eilks, 2010)
Press and broadcasting news	Journalist method (Marks, Otten & Eilks, 2010)	Shower gels (Marks & Eilks, 2010)
Product testing	Product test method (Burmeister & Eilks, 2011a)	Plastics (Burmeister & Eilks, 2011)
Advertising	Creating advertisements	Sweetening agents (Lippel, et al., 2012)

Table 1: Teaching examples for the imitation of societal practices

EXPERIENCES AND IMPLICATIONS

Science teaching has constantly been a target of criticism. It is, i.e. in the fields of chemistry and physics, perceived as being uninteresting and irrelevant by pupils. The usefulness and value of the subject matter taught and competencies learned in science, i.e. chemistry and physics, class remain frequently unrecognized. The here presented approach, documented up to today for more than 15 different units and developed and tested by Participatory Action Research in science education (Eilks & Ralle, 2002) documents that a thorough orientation on controversial and authentic socio-scientific issues can provide a fruitful alternative.

Numerous case studies testing the socio-critical and problem-oriented to chemistry and science teaching (e.g. Eilks, 2002; Marks et al., 2008; Marks & Eilks, 2010; Feierabend & Eilks, 2010; Burmeister & Eilks, 2011), provide a whole set of evidence that a stronger orientation towards society and a more attractive structuring of material both represent enrichments to teaching, which may possibly help to reduce the deficits discussed above. Learning about the interconnectedness of science, everyday life, and society has continually shown itself to be a motivating factor. This always was one of the positive factors in the feedback and evaluation of respective lesson plans. Anyhow, aside the motivating factor positive feedback especially focused the alternative methods of teaching, i.e. creative ways of contrasting different points of view in the mimicked authentic practices. Here methods providing clear structure (e.g. the journalist method by Marks, Otten & Eilks (2010), the consumer test method by Burmeister & Eilks (2011), or developing advertisings by Lippel, Stuckey & Eilks (2012), are considered to be more fruitful than the often more demanding methods of role plays and business games. For motivating and explaining the use of mimicking authentic social practices the idea of filtered information has proven itself to be a valuable construct. This is true for both lesson planning and reflection, but also for discussing with pupils how science is dealt with by society.

After the intensive trials of the examples presented here in different groups of Particpatory Action Research, we are convinced that science lessons following this path represent an important contribution to broad-based, societally relevant learner competency in communication and evaluation in the sense of general educational goals. Our experience also reveals, however, that not only pupils, but also their teachers, can learn and benefit greatly from the intentional networking of science, technology and society. Therefore, respective lesson plans and methods should be more thoroughly incorporated into the practice of science teaching.

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SCIENCE EDUCATION FOR CIVIL SOCIETY: BRIDGING THE GAP WITH MICHEL FOUCAULT AND PIERRE BOURDIEU

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Abstract: Taking as a starting point – or "as a startling point" as one might say – the phenomena that occur when moving within the two fields of science education and civil society, the article gives a short overview of the fields of science education and of civil society and how they look at each others objects of description respectively. A veritable white spot on the map between theories of civil society and of science education is detected and found to be both fascinating and disturbing. To bridge the split the philosophy of Michel Foucault and the sociology of Pierre Bourdieu are considered. An exposition of elements of the works of M. Foucault and P. Bourdieu supports the argument that both are helpful in understanding how science education for civil society may function.

Keywords: civil society, epistemology, philosophy, bourdieu, praxeology

INTRODUCTION

Providing a short overview of the fields of science education and of civil society and how they look at each others objects of description respectively, this article describes a veritable white spot on the map between theories of civil society and of science education. The author considers the philosophy of Michel Foucault and the sociology of Pierre Bourdieu to bridge the split. An exposition of elements of the works of M. Foucault and P. Bourdieu will support the author's argument that both are helpful in understanding how "science education for civil society" may function.

A STARTING POINT

Data collected as a participant observer in the two fields of science education and civil society in Germany over several years (as a science teacher, as a committed citizen, but also as a science student and later as a doctoral candidate) led the author of this article to a hypothesis inter alia that in most Germans' everyday thinking, the undertaking of science education in school is not or only very weakly linked to participation in a civil society (Geiger, 2009). A similar split can be found, when looking into the theories that describe and (re-)construct civil society and science education:

THE TWO FIELDS

To gain an overview of the theoretical construction work that is done on the field of German science education, one can take a look, for example, at the list of contributions to the 2010 annual conference of the German Association for the Didactics of Physics and Chemistry (GDCP 2010) or into the German journal for the Didactics of Science (ZfDN 2010). Even though the 2010 conference was titled "Naturwissenschaftliche Bildung als Beitrag zur Gestaltung partizipativer Demokratie" (translated: "Science education as a contribution towards participative democracy"), the topic of its title can be found almost nowhere in the contributions. Apart from the keynotes, only 7 out of 147 single oral presentations explicitly address participation, democracy or civil society. A first look into ZfDN gives a similar picture: There is a small fraction of authors making notions towards a democratic society. But the links are drawn more or less in “hand waving” manner, mostly with the purpose of providing moral background support to their special approach within the field of science education. Detailed models or empirical evidence of concrete links between science education and the functioning of civil society are never mentioned as an integral part of the reasoning on the science education side.

The split seems to be even wider, if one looks into the common theories of civil society. Heins (2002) and Schmidt (2007) give an overview of authors like Alexis de Tocqueville, Max Weber, Antonio Gramsci or Hannah Arendt. Even though these authors have been constructing their theories while industrialisation (and thus the growing importance of scientific knowledge within society) was already fully on its way, none of their theories seem to contain any important notion towards science education. It is the same with more recent authors like Barber (2003) or Walzer (1992). Although Barber talks of “politics as epistemology” and later gives a detailed and concrete list of institutions to be introduced into our democratic societies, there is not a single substantial word on science education.

While the view on the bodies of the different theories can and has still to be improved, the division between the theories in the two fields is already clearly visible. It seems that we are still in the era of “The Two Cultures” of 1959 (Snow, 1993).

SORROW AND FASCINATION

The split between science education and civil society theories is both fascinating and disturbing at the same time. One only has to take into account two commonplaces: 1. To a high degree, the very fabric of modern societies is made of and sustained by technologies and their underlying scientific knowledge. 2. The stability and healthy transformations of modern liberal democracies are regarded as hinging on active civic participation of their citizens (e.g. Barber, 2003). Both put together, the theoretical unconsciousness regarding the interdependencies between science education and civil society appears as a major impediment, probably imposing itself onto the necessary and certainly ongoing transformations of existing democracies. This unconsciousness furthermore indicates that there are sub-surface mechanisms, probably of various kinds, that foster the existence of that split.

TWO SCHOLARS IN BETWEEN

Once again when looking for theoretical frameworks to bridge the gap, my aforementioned empirical findings of the participating observations in the two fields of science education and civil society serve as a starting point. The works of Michel Foucault (1926–1984) and Pierre Bourdieu (1930–2002) seem to prove particularly helpful in trying to find theoretical explanations and descriptions for those findings. I will present some exemplary elements of the works of Foucault and Bourdieu, to demonstrate that both of them are able to shed light onto some important aspects of what lies in the dark between the two fields.

A striking similarity between Foucault and Bourdieu is, that their works are explicitly aimed at barriers of perception easily escaping our consciousness. Both follow different pathways to accomplish the unveiling and possible dissolution of such barriers. Foucault, for example, somehow travels in time – or rather history – via documents of the past, whereas Bourdieu travels in space – examining cultures to be found with the groups of different places. By displacing themselves, they both gain distance to our present and here. Looking back from what they find at their distant places, our European society at the end of the 20th century suddenly starts looking alien, coincidental – sometimes even comical ! – thus revealing some of its implicities, that would not have otherwise been seen at all, or would have passed as normal, necessary, natural.

Michel Foucault

Michel Foucault was interested throughout all of his works in the different relationships between knowledge, power and humans. He took special interest in how humans become subject to those relations by techniques, technologies and practices.

His works are situated exactly along the axes that are being of interest to the research of links in between the two fields. An example would be one of his later lectures (Foucault, 2009): He analyses the relationships between human subjects and truth and the practices humans use or have to use to gain access to truth. In this lecture, he describes something he calls the “cartesian moment”: From that certain moment on – it is a long and discontinuous road leading to that moment – one can say that legitimate, justified truth is won by and only by perception of objects and knowledge on objects. From this moment on, truth has become objective truth. As such it is the basis of modern science. And it is separated from the subject perceiving it: We discuss and quarrel about methods and we require that a researcher is honest, is rational and has undergone some training. But once we agree on the methods and those prerequisites are met, the knowledge acquired is objective truth, independent of the person researching. By examining some mainstream philosophies of the 1st and 2nd century, Foucault shows that there have been other reasonable concepts of knowledge and truth: In stoic and epicurean thinking, knowledge was to link the individual subject to the world and the worldly objects – it was subjective knowledge. A teacher was seen as speaking the truth only, if his speech was able to lead his listeners towards autonomy from the speaker.

One only has to take a look at today’s practical circumstances between experts and non-experts, teachers and students to realize the differences ... A hypothesis, among others, that could be drawn from Foucault's historical perspective on truth above would be, that the truth dominating science education is an objective type, whereas the kind of truth that is needed in and would be helpful to the processes of civil society would be both objective and subjective. It would arise, for example, from working on questions like: “What does that objective truth mean to me personally (as citizen among others)?” Problems arise, if one wants to integrate that work on subjective truth into science education: The institutional practices of grading students' performances are constructed as objectifying acts of the teachers on the students and their works.

Pierre Bourdieu

Pierre Bourdieu has conducted vast and huge sociological explorations (some call his style of work an “academic mega-enterprise”) into various fields of society, including the academic field (Bourdieu, 2006) and the educational system (Bourdieu & Passeron, 1971). Throughout the various research campaigns and heavily relying on empirical data, Bourdieu constructed a complex, dynamic, accurate, comprehensive and up to now almost unchallenged theory of modern society.

An exemplary element of Bourdieu's theoretical framework that stems from his cross cultural observations is his concept of “dispositions” (an easily accessible description can be found in Bourdieu, 2005): This concept indicates that it is impossible to change an unequal society via simple acts of cartesian cognition (that is, by objective knowledge). Bourdieu is able to show that the individual and collective abilities to participate in society are written into peoples' bodies and minds and that those abilities correlate with their social positions and milieus. The social conditions of society are so deeply written into bodies and minds, that their effects on behaviour and perception of reality are not easily accessible by conscious efforts.

CONCLUSIONS

Looking at the state of my work, I can say that it is still far too early to draw anything like a blueprint of what science education for civil society could or should look like. Yet both Foucault and Bourdieu help identify possible elements of reflection and consideration: The small fraction of Foucault's work given above suggests that it would be worth putting an analytical focus on the conscious and unconscious gestalts of truth that play a role in science classes and in civil society. Pierre Bourdieu's concept of dispositions shows us that individuals are unable to really participate in political processes on the basis of their (cognitive) scientific knowledge alone: If science education is meant to emancipate people, it cannot ignore the effects of bodily incorporations and social environments of students and teachers. In one way or the other, it has to address those fields of learning, too.

Many concepts of science education that do this exist already, both in theory and practice. Working towards a science education for civil society would therefore certainly not mean re-inventing the wheel. But it would mean drawing lines between those concepts and civil society on a theoretically and empirically solid basis, thus introducing some new aspects and new input into both. On the side of science education, I think this bears the clear opportunity to further develop and extend (or in some cases to revive and rejuvenate) progressive approaches like “la main à la pate” (a collaborative hands-on approach), teaching history of science, STS or project-oriented teaching.

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INFLUENCE OF EXTERNAL ASPECTS ON STUDENTS' EVALUATION AND JUDGEMENT COMPETENCE IN CHEMISTRY

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Abstract: This study is based on the National Educational Standards (NES) in chemistry for the final exams at middle schools (KMK, 2005a, b, c) in Germany. The Institute for Educational Progress (Institut zur Qualitätsentwicklung im Bildungswesen - IQB) evaluates and develops the NES in cooperation with institutes for science education at different universities in the project ESNaS (Evaluation of the National Educational Standards for Natural Sciences at the Lower Secondary Level). The NES covers 4 areas of competence which are: a. content knowledge b. acquirement of knowledge (scientific inquiry) c. evaluation and judgement and d. communication. The project presented in this paper is limited to the *evaluation and judgement competence*, only. The presented study's aim is to clarify how students' evaluation and judgement competence is influenced by external aspects. Therefore items are developed and used for the assessment of 780 students in Germany.

Keywords: assessment, evaluation and judgement, Chemistry, standards, paper-pencil-test

FRAMEWORK

Amongst others, the National Educational Standards (NES), which are established by the Standing Conference of the Ministers of Education and Cultural Affairs, define competences for the scientific subjects (biology, chemistry and physics) and have been implemented in Germany after the school year 2005/2006 because of unsatisfying results in international studies like TIMSS and PISA. Students should have acquired these competences when they graduate from middle schools after grade 9 or 10 (depending on the school type). The standards are described for different areas of competence (*content knowledge*, *acquirement of knowledge, communication* and *evaluation and judgement)* (KMK, 2005) and are evaluated and enhanced by the Institute for Educational Progress (IQB) in cooperation with institutes for science education at different universities in the project ESNaS.

The NES define the *evaluation and judgement competence* in chemistry as the ability to detect and evaluate chemical topics in different contexts (KMK, 2005). In recent research projects in biology the *evaluation and judgement competence* is defined as the ability to decide justifiedly and systematically in complex problemsituations with different options of behaviour (Bögeholz et al., 2004). According to Poschmann, Riebenstahl, & Schmidt-Kallert (1998), an evaluation process consists of a minimum of three elements (object, subject, connection between object and subject). During this process criteria have to be identified, evaluation strategies have to be used and finally a decision has to be made (Jungermann, Pfister, & Fischer, 2005). Test items in the context of *evaluation and judgement competence* normally do not have a clear or single solution and, as socio scientific issues (SSI) in general, offer controversial opportunities (Sadler, Donnelly, 2006). These issues are mostly social, complex and open-ended problems related to science (Sadler, Barab, & Scott, 2007). They can be negotiated from multiple perspectives (Sadler, 2004). Topics represented in these issues are, for example, global climate change, energy choice or genetically modified food (Albe, 2008).

There are competence models for the evaluation and judgement competence in biology only which are specified on some aspects of the evaluation and judgement competence (Eggert & Bögeholz, 2006; Mittelsten Scheid & Hößle, 2008) but they cannot be directly adapted for chemistry.

It can be assumed that there are additional external aspects which influence the *evaluation and judgement competence*. These external aspects are not part of the evaluation and judgement competence itself but may be important control variables when measuring the *evaluation and judgement* competence. Recent research projects showed that high content knowledge effects the quality of argumentation (von Aufschnaiter, Erduran, Osborne, & Simon, 2008) and showed a relation between content knowledge and the negotiation of SSI (Uskola, Maguregi, & Jiménez-Aleixandre, 2010; Sadler & Fowler, 2006). In addition to that, it can be assumed that social desirable responding could have an influence on students' answers in surveys (Sedlmeier & Renkewitz, 2008). To assess the *evaluation and judgement competence* tasks are used which contain environmentally conscious behaviour. Under expectation of an environmentally conscious behaviour, corresponding attitudes are assumed (Kaiser, Wölfing, & Fuhrer, 1999). Critical thinking is one requirement for the *evaluation and judgement competence* and contains the evaluation of data quality (Astleitner, Brünken, & Zander, 2002) and students need to know what evaluation strategies are and they have to apply evaluation strategies to evaluate precisely.

The possible external influential aspects can be divided into the three following categories (figure 1):

1. Subject-related aspects, which include the content knowledge and the application of content knowledge, related to the topics of the items.

2. Interdisciplinary aspects, which include knowledge and application of evaluation strategies and estimation of data quality.

3. Personal aspects, which include individual attitudes, social desirability and cognitive abilities.

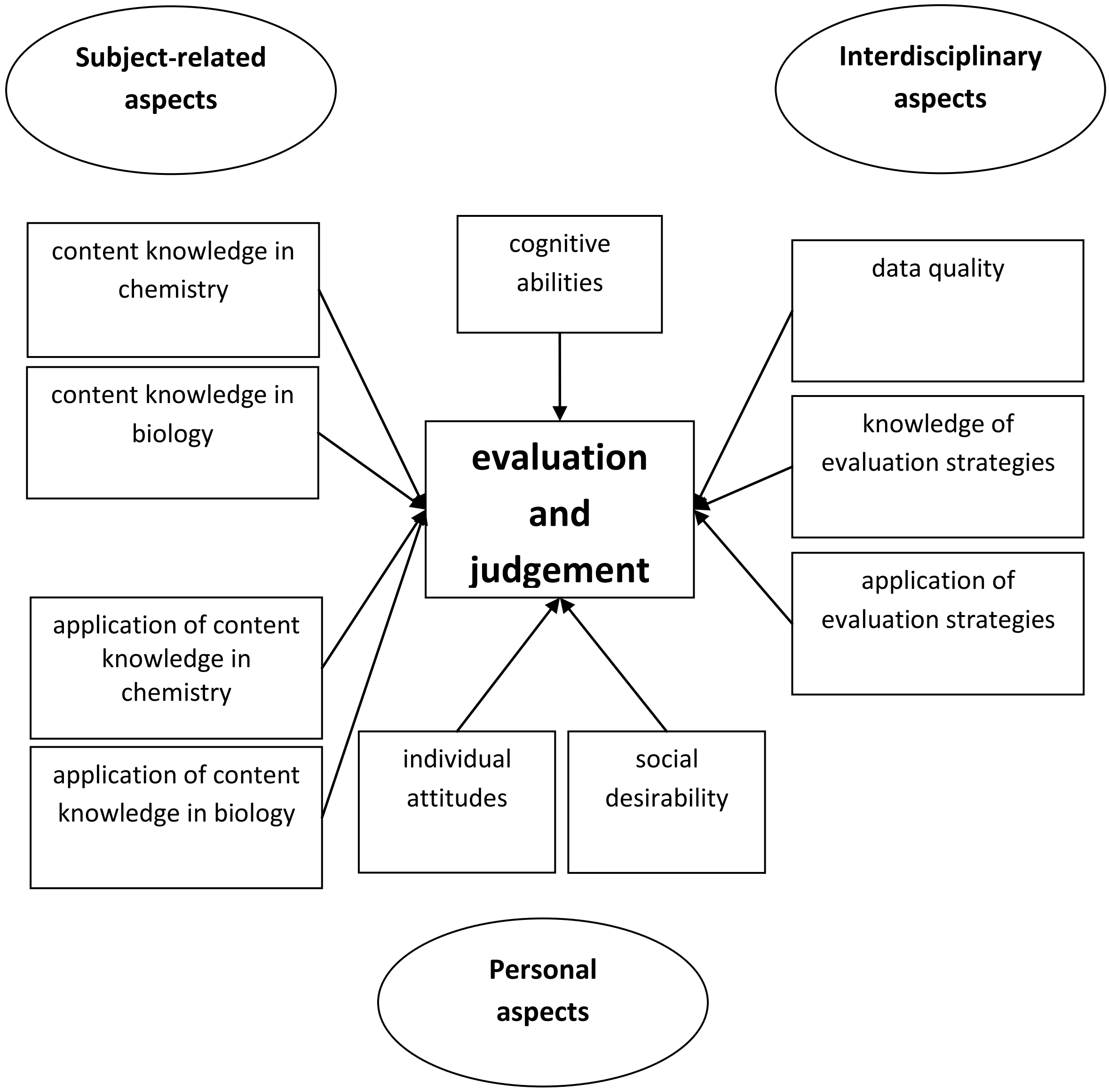

figure 1: assumed external infuential aspects

Methods

For data collection a quantitative empirical design was used. To assess the *evaluation and judgement competence* in chemistry, students had to work on paper-pencil-tests constructed in a balanced incomplete block design. In test items students were asked to identify criteria to make a decision in controversial situations, to use evaluation strategies and to reflect decisions. Additionally, the following tests concerning the assumed influential aspects were used.

- Test on content knowledge and application of content knowledge. This test was constructed in a balanced incomplete block design and the students receive the items which match the items they had in the test on the *evaluation and judgement competence.*

- To test whether the students evaluate because of social desirability, the German version of the balanced inventory of desirable responding (BIDR) was used (Paulhus, 1998; Musch, Brockhaus, & Bröder, 2002). This test consists of two scales, which have 10 items each. Social desirability is divided into two distinguishable components. While one component is self-deceptive enhancement, the other component is impression-management. Each of these components can be measured with the BIDR because of a two factorial loading structure and good convergent and discriminant validity (Musch et al., 2002).
- The cognitive ability test (Heller & Perleth, 2000) was used to control the influence of intelligence.
- A test on knowledge and application of evaluation strategies in everyday life context
- A test measuring the students' estimation of data quality
- A test concerning individual attitudes concerning environmental aspects (Frey et al., 2009)

The time needed by students to fill out the tests and questionnaires was 180 minutes and data was collected in two days. To recapitulate, there was a test concerning the chemistry specific *evaluation and judgement competence* and tests concerning all possible external aspects (figure 1) influencing the *evaluation and judgement competence*.

RESULTS

All in all, the sample of the main study included about 780 students from grade 9 and 10 of German secondary schools (Gymnasium). Due to the balanced incomplete block design each of the items in the test on *evaluation and judgement competence* and in the test on content knowledge and application of content knowledge is done by 142 students. The fit-parameters and the item difficulty of the test items are investigated by Rasch analysis. All of the items fit the criteria of quality weighted mean square value (.75-1.33) and t-value (-2.0 – 2.0) (Wilson, 2005). By using Rasch analysis, person parameters for each test are identified which can be used to investigate the relations between the tests. To find out to which degree different factors influence students' evaluation and judgement competence, correlations and regressions were calculated and path models were evaluated. While the highest correlation is between the *evaluation and judgement competence* and the application of evaluation strategies ($r = .294$, $p \leq .001$), the cognitive abilities ($r = .265$, $p \leq .001$), application of content knowledge ($r = .298$, $p \leq .001$) and the estimation of data quality ($r = -.267$, $p \leq .001$), there is no connection between the *evaluation and judgement competence* and the individual attitudes concerning environmental aspects and between the *evaluation and judgement* and social desirability. The calculation of linear regressions shows that most of the variance for the *evaluation and judgement competence* in chemistry can be explained by the ability to apply evaluation strategies in everyday-life situations ($ß = .21$, $p \leq .05$) followed by the ability to apply content knowledge ($ß = .19$, $p \leq .001$). In addition to the calculation of correlations and regressions, a path model shows the interaction between some influential aspects and fits the criteria of quality like RMSEA, CMIN/df, SRMR, CFI (figure 2).

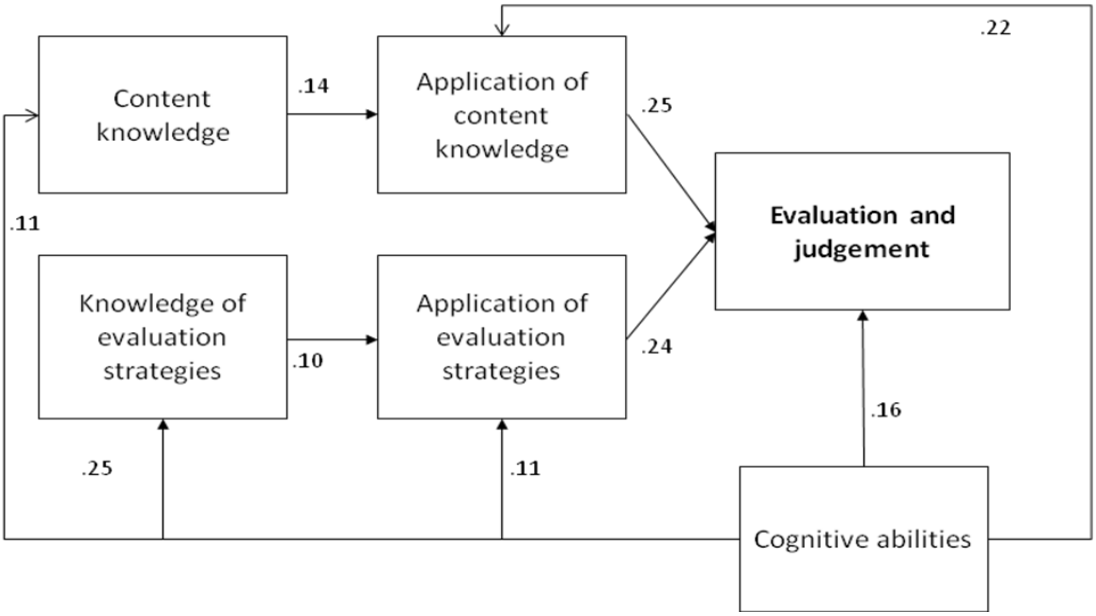

Figure 2: pathmodel for the interaction between the aspects

By using the other influential aspects in the model (social desirabilitiy, individual attitudes, estimation of data quality) the path model does not fit the quality criteria anymore. In addition to the interaction of the aspects represented in the path model, two mediation effects can be found. First the effect of content knowledge on the *evaluation and judgement competence* is mediated by the application of content knowledge. Second, the effect of knowledge of evaluation strategies on the *evaluation and judgement competence* is mediated by the application of evaluation strategies.

CONCLUSION

The data of this study provide an overview on students' *evaluation and judgement competence* in Germany. Furthermore, the study shows how the *evaluation and judgement competence* is influenced by external aspects. In summary specific abilities are needed to effect a high *evaluation and judgement competence*. One predictor for this competence is the application of evaluation strategies in everyday-life situations and in addition to that, specific content knowledge is needed. With this knowledge, students' competence can be measured, developed and trained more systematically.

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PHOTOVOLTAIC AS A POSSIBILITY TO GAIN "GREEN ELECTRICITY"– A SOCIOSCIENTIFIC ISSUE TO INCREASE STUDENTS' ABILITY OF DECISION MAKING

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Abstract: The task of socioscientific issues has not yet been settled in German physics classes, although the National standards of science education require the implementation of such topics in class. In response to the obvious gap between educational research and daily school practice we created a teaching unit to reduce this gap. The socioscientific issue and the topic of the created unit is the use of photovoltaic to gain "green electricity". The unit contains photovoltaic experiments for students, explicit knowledge training for decision making, following the research in biology education by Boegeholz et al. (2006), and discusses the impact of this new knowledge regarding the social community. Our teaching unit aims at the increase of students´ ability to make decisions. An empirical study is conducted to evaluate the teaching unit. Due to the lack of test instruments to measure decision making processes in the context of physics, we developed a standardised questionnaire that we apply to our evaluation study. This instrument and the corresponding teaching unit were tested in two pilot studies. In October 2010 the main study has started and the data collecting ended in summer 2011.
In this paper we present the theoretical background and the conception of our evaluation study, our findings of the first and second pilot study and finally an outlook on initial findings of the main study.

Keywords: socioscientific issues · photovoltaic · teaching unit · decision making · measurement

THE STUDY

Our study consists of 2 connected parts. In the first part we developed a new teaching unit which we called PEBU. In the 2nd part our study aims at testing and evaluating the teaching unit in class. PEBU is an acronym that links at the central elements of our teaching module which are photovoltaic, energy, decision making and environment (German: Photovoltaik, Energie, Bewerten, Umwelt). The implementation of explicit decision making training into a photovoltaic teaching unit is the distinguishing mark of our new approach.
The aim of our study is to create a physics teaching unit which enables a verification of the teaching success of science knowledge as well as the competence in decision making in the socioscientific environment.

CONNECTION TO THE CURRENT RESEARCH LANDSCAPE

The National standards for science education in Germany postulate that the goal of every science class should by to develop four competencies within the "regular science teaching" (Kultusministerkonferenz, 2005). These four competence areas are: scientific knowledge, scientific inquiry, communication and decision making. Excellent science teaching practice has always aimed at unfolding these competencies, but now they become an official claim which means that there must be an implementation. This generates a lot of research concern-

ing all four competencies. However there is a gap between research and school practice. But there are studies trying to conquer this gap.
Three interesting research approaches from different parts of educational science research are presented as an example of a great variety of studies.

1. There is the participative approach used in the current chemistry research (Eilks & Byers, 2009). This approach is based on authentic and socially relevant problems which can be solved using chemistry knowledge. Due to the fact that multiple correct solutions exist, the selected solution depends upon the person that solved the problem.
2. Then there is the SSI approach established in the USA (Sadler & Donelly, 2006). This approach claims that the best contexts for decision making problems are socio-scientific issues. A “socioscientific issue” is described as a controversial social issue with conceptual, procedural, or technological ties to science. This approach is highly accepted within the community and many studies are following this path.
3. The third presented approach is the “Goettinger-Modell” (Eggert & Boegeholz, 2006) developed in German biological science education research. This structural model postulates four constituent competencies and for each of them a progression of four graduations of difficulties.

According to the above presented examples our topic of photovoltaic is extremely appropriate. Measured with the ideas of the participative approach, the topic is socially and ecologically relevant and authentic. Dealing with it demands physics content knowledge. The topic also fits into the SSI approach and the usage of the Goettinger model is extremely suitable to the study presented here, and it is therefore used as a guideline.

THE TEACHING UNIT PEBU

The content of our teaching unit is an aspect of ecological building, namely the use of photovoltaic to produce electric energy. The students will consider this specific topic from a broad perspective and discuss their findings. The goal of this unit should be to guide the students to become reflective and independent individuals which are capable of making decisions in complex situations. On one hand the students get the chance to learn the physics of photovoltaic plants by conducting many experiments and on the other hand they get in touch with economic problems like cost-benefit-analysis or social problems like the influence of press coverage on public beliefs. In addition the students are confronted with different strategies of decision making and they get opportunities to exercise these strategies in the method training and in the following lessons.

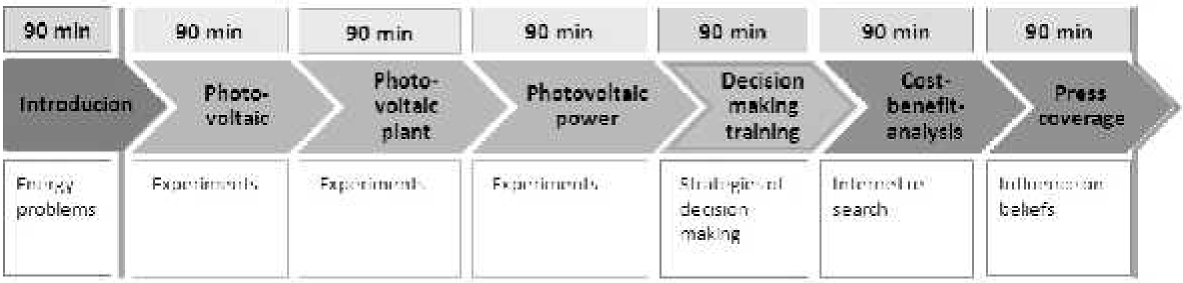

Figure 1: Design of the teaching unit PEBU

CONCEPTION OF THE EVALUATION STUDY

The following research questions build the focus of our evaluation study:

1. Is the topic of photovoltaic within the reach of students’ interest?
2. Is the teaching unit PEBU able to increase the ability of decision making?

   a. Which conclusion can be made with respect to the development of decision making competence?
   b. To which extent are the changes in decision making produced by the complete teaching unit still applied six weeks later?
   c. To what extent is the explicit decision making training able to increase the ability of decision making?
3. Can different decision making strategies be detected?

Our questionnaire entails three different parts. The first block contains Likert-Items to evaluate the students´ interest in photovoltaic and ecological building. The second block consists of several complex situations in which the students should make their decisions. These decision items are open items as they show the decision making process and the corresponding reasoning. The last block of the questionnaire is the knowledge block. It contains items to evaluate the content knowledge which should be gained by the PEBU teaching unit. We tested this questionnaire two times. The first pilot study was realised with third semester students from the University of Education Freiburg (average age of 25). The findings of this first study lead to a revision of the questionnaire and the design of the teaching unit. In the second pilot study we re-tested the new measuring instrument with 150 college students (average age of 14). Parts of the findings of the pilot studies are presented below.

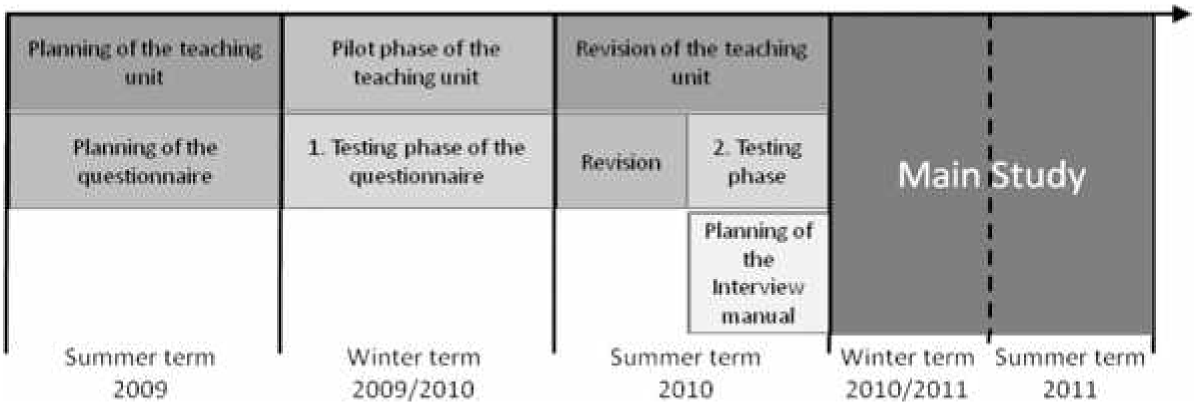

Figure 2: Timeline of the study

FINDINGS OF THE PILOT STUDIES

The first pilot study showed that the first version of the questionnaire was able to measure the teaching unit's impact students's knowledge increase. We could verify a highly significant increase of knowledge. However, it should be mentioned that the students, despite the improvement, were not able to answer more than 50% of the knowledge questions after teaching. From this followed that the knowledge improvement has not reached its maximum, and this lead to a revision of the teaching unit. The decision making block of the first version of our questionnaire contained five open questions which were treated with qualitative content analysis. The goal of this part was to evaluate the number and kind of mentioned assessment criteria as these findings are linked to the ability of understanding a complex situation and the ability of analyzing the problem from different angles. These aspects can be used as indicators for the decision making ability of the students. In the first pilot study we could not find an increase in the decision making ability. This finding is the reason for our hypothesis that it is not possible to increase students´ decision making ability by just teaching expert knowledge without discussing decision making on a meta-level.

For the 2nd pilot study, the first block of the questionnaire, containing the interest-items, remained unchanged because the results can be transformed into 4 scales of interest with good reliabilities and the second study supports the findings of the first study. The knowledge part of the questionnaire was not part of the re-testing process as the participating students tested only the questionnaire without the teaching unit. However, the results of this part of the questionnaire from the first pilot study were satisfactory. The test of the second pilot study still contains a decision making block but with even wider items. There are now four categories of decision-items. First an easy item where the situation is described and all needed information is provided so that the students only have to make the last step and decide on one of the possibilities. In the second part the sitation is described and pieces or advice of three friends are given. The student has to think of the advantages and disadvatages of every advice before he or she takes a decision. Then in the third part the situation is described and all information needed is hidden in the text so that the students have to read, comprehend and decide for one possible reaction. In the last part the situation is descirbed as well as two decisions of two other people and the students have to decide which decision making strategy is best. The pilot study detected that the third item type was too difficult for the pupils and was, therefore, changed for the main study. The other three where successful and are used unchanged.

THE MAIN STUDY

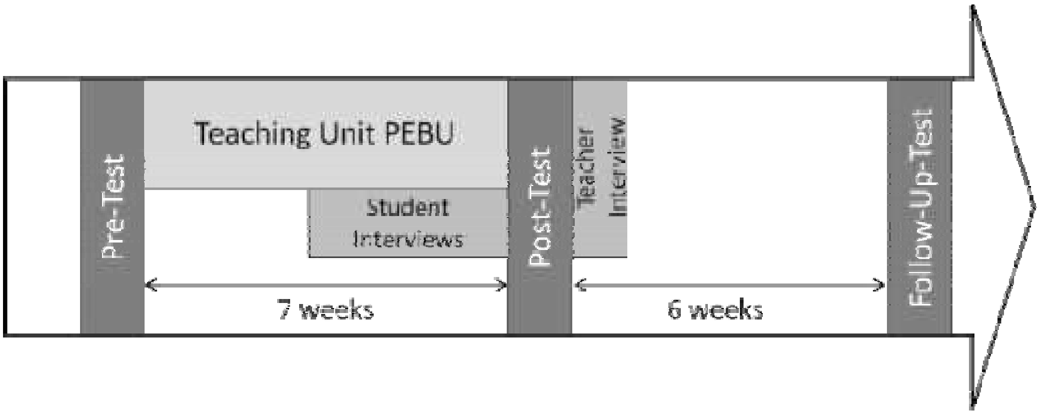

Figure 3: Design of the main study

To gain information about the decision making strategies of the participating students, we created a questionnaire which we tested and retested in two pilot studies. The first study showed, that the questionnaire is able to measure the students´ impact of knowledeg as well as the students´ interest in photovoltaic. The pilot studies caused a revision of the decision making block. Now the questionnaire contains three successful item types, which we will use in our main study.

The main study started in October 2010 and was concluded in summer 2011. The experimental group has six participating schools with approximately 200 students. The control group contains of 4 classes comprising 100 students.

The decision making competence and the content knowledge was evaluated by our tested instrument in a pre-, post- and follow-up-design. To gain additional information concerning the development of the decision making competence several students were interviewed. After the teaching unit there was an interview with the teacher to evaluate the teachers' perspective and his or her understanding of decision making in socioscientific environments.

INITIAL FINDINGS

In this paper we like to present our first answers concerning the third research question 'Can different decision making strategies be detected'. After the collection and compilation of our data we detected three main strategies of decision making. Valuation method I is an intuitively based decision, method II contains decisions which uses either the cut-off or the list of benefits their main strategy and finally people using the trade-off strategy fall in to the category of method III. This finding does not represent the whole effect of our intervention but Figure 4 shows the percentage of each evaluation method.

Difference between question type 1 and 2
The findings for question type 2 are nearly unchanged in Pre-, Post- and Follow-up-test. While the findings for question type 1 change slightly but stay clearly different from type 2. This difference is not surprising as question type 2 is clearly more difficult than type 1. This may also be an explanation for the most frequent use of the valuation method I (intuitive). In contrast, the easier questions type 1 was often solved by using a more complex method.

Change in answering type 1 questions
The used strategy for dealing with questions of type 1 changed over time in this population from demanding to more intuitive. As can be seen by comparing the shape of the bar diagram. From our point of view there are two reasonable explanations:

1. Possibility: *Fatiguing effect* by confronting the students with the same question type.
2. Possibility: *"Expert" effect* by not writing down every little step.

Application stability of the chosen method
In this population the frequency of method III question type 1 in the Pretest is surprisingly high. But in the following tests method II turns out to be the only stable solution strategy for this type. For question type 2 on the other hand the detected strategies are immediately stable, means that students do not change their strategies between the three tests.

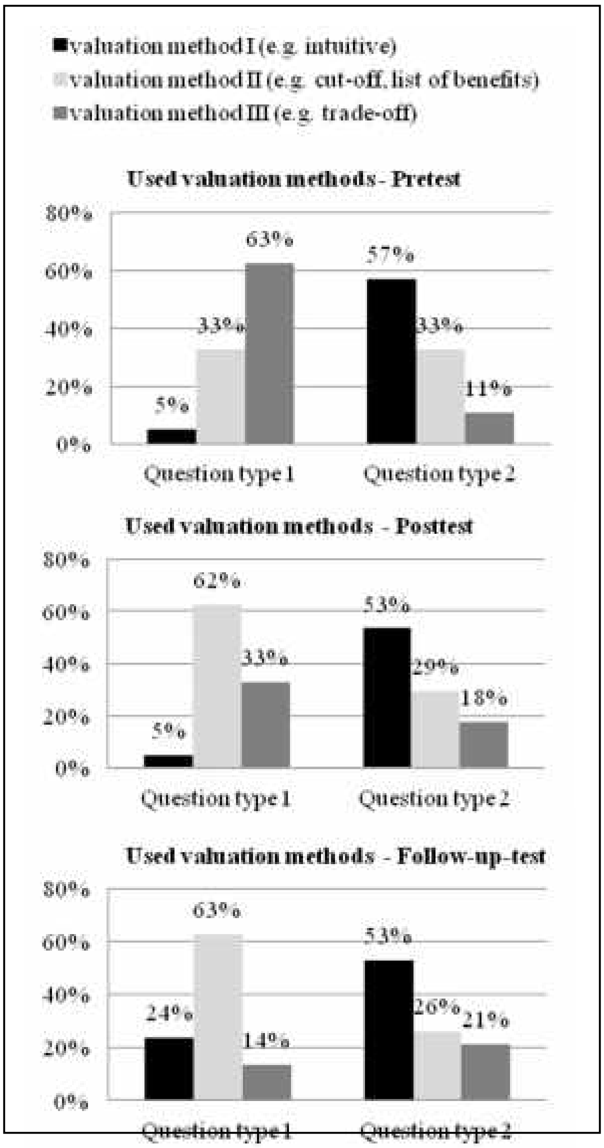

Figure 4: Detected decision making strategies (type 1: buying situation, type 2: discussion with friends)

CONCLUSION AND OUTLOOK

Our Data lead to the conclusion, that students use three different methods of decision making. The choice of method depends on the question type and the corresponding degree of difficulty. The more complex the question gets the more basic the chosen method. If the question type is demanding then the choice of the method is very stable. For simple questions type 1 (e.g. buying decisions) we observe a decrease of the use of complex methods. This observation may be caused by either a fatiguing or an "expert" effect.

In our further research the combination of our different sets of data will be used to answer the research question 1 and 2. The second question will be the challenging one as the data suggests there is a strong relationship between the chosen decision-making strategy and the given context. This important connection, however, is not part of our guiding structural model, the

“Goettinger-Modell”. The main task is therefore to advance the given model to analyze the possibility of increasing students´ ability of decision making within the teaching unit PEBU.

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ASSESSMENT OF THE EFFICIENCY OF EDUCATION FOR SUSTAINABLE DEVELOPMENT IN COMPULSORY SCHOOLING: TOWARD RELEVANT INDICATORS

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Abstract : Education for sustainable development differentiates itself from the customary educational situations. The challenge is not only to adapt social issues to a school context but also to participate in collective experiences of development according to a mission of implication and of preparation of the actors for their role in society. Educational actions, like collective experiences, fulfill the requirements for the incorporation of *dispositions* – attitudes, abilities, beliefs - (Bourdieu, 1998) for choosing, for deciding and for acting. But an education focussed around “dispositions” transforms evaluation for researchers and practitioners. Thus, having indicators becomes a strong challenge and we then need to have a theoretical model of the commitment in action. For instance, H. Joas (1999), about the human action, distinguishes intentionality, corporeality and social instincts. Evaluating the changes in pupils ‘attitudes and commitments requires from the teachers to have indicators enabling them to take those distinctions into account. This contribution aims at discussing the functional organization of selected indicators. This prospective work has been established thanks to pieces of data collected from three projects conducted in primary and secondary schools during three years.

Keywords: Education for sustainable development; curricular approach; educational action; educational indicators

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BACKGROUND AND PURPOSE

The idea of Sustainable Development (SD, below) requires that we collectively work a development out which takes into account environmental, social and economic issues raised by social groups to the conflicting interests (Aubertin and Vivien, 2006). SD induced in itself or through its fundamental principles, such as the precautionary principle, the willingness to anticipate a better evolution of human societies in an enlarged temporality with the goal of controlling the future. This is a progressive and irreversible process: a broadening of the field of the political action, not only to the human being as a species, but to the entire biosphere (Doron, 2009). In France, in relation with the recommendations policies such as those of the commission chaired by Brégeon (2008), two missions for compulsory school (School, below) may be defined: a mission of participation and a mission of preparation of actors to the dynamic of transformation of society. The challenge for School is not only to adapt some socio-issues but to allow the participation of pupils to collective experiences like a real and repeated “educational action”. "Educational actions" indeed enable the incorporation for “dispositions" initiating deep tendencies to choose, to decide and to act now and later (Bourdieu, 1998). “Dispositions”, means the whole of standards, attitudes and beliefs which encourage people to act or inhibit them. These dispositions are the central point of these educational situations (Lange and Martinand, 2010) and may be the subject of learning. Thus, the current participation in actions to SD prepares the actors thanks to the constructed “dispositions”.

RATIONALE

The choice of effective actions of SD as an educational modality requires the development of new strategies of evaluation: it cannot be one of the customary modalities of evaluation of knowledge or a *skills* assessment through observable *performances.* Indeed, who could judge a performance of sustainability? Various works under the aegis of the UNESCO, have proposed some general principles for the development of indicators. In agreement with Rode (2006), three levels should be distinguished: a "macro" level or level of educational policy, the target of works managed by UNESCO, a "meso” level of educational institutions, a "micro" level for the class or for the educational project. Our work aims at developing "micro" and “meso” indicators allowing an assessment and regulating “educational actions”. Having indicators is necessary both for the teachers as an indication of the supports and obstacles exist with learners, and for the actors (teachers and pupils) of the project as a way to evaluate, and to regulate the action. These indicators can be divided into three categories as follows: sustainability, suitable knowledge and incorporated dispositions. But these dispositions are not observable. How then render an account of it? How to make them operational linking them with objective criteria?

The subject of this contribution is to identify indicators that can be observed or collected through the speeches and aims the empowerment of the actors involved in the project of ESD in order to enable them to make choices as to strategies.

METHODS

Coming from the field of sociology, the idea of indicator proposes to develop observable variables to account of a reality not noticeable immediately. We can thus distinguish between: indicators, lists of indicators, aggregated indicators or index (Boulanger, 2004).

Aggregated indicators, or index, are a tool for the evaluation of public action for public use and may become the privileged instrument of an active and critical democracy in allowing the perception and understanding of the externalities. Finally, our project is to develop a qualitative index of the efficiency of educational actions of SD.

A synthetic index is built in several stages (Table 1).

Stage	**Characteristic**	**Objectivity/Subjectivity**
Identification of scientific concepts	multidimensional	In principle objective
Selection of relevant variables	Qualitative, quantitative, semi-quantitative	Objective but choice in view of the project
Measures	Determination of scales, the degree of precision, the thresholds	Objective but elements of subjectivity in choice
Operational	Synthesis : single index	Step the more subjective and more contested

Table1: Stages in the construction of an index (from Boulanger 2004)

Incorporating the approach proposed above, this work was carried out in three times:
- Meta-analysis of the theoretical corpus concerning the theories of action (Baudoin, J-M. and Friedrich, J., 2001).
- Selection of the theoretical framework according to a principle of consistency, and then the development of a theoretical framework
- Empirical validation of the feasibility in the third level in primary school, the lower secondary school, and the first level of the higher secondary school, in the existing institutional framework. This step is the result of placing in correspondence with the categorizations carried out in a previous study (Lange et al, 2010) by means of a content analysis (Bardin, 2001) of the students’ speech.

In a first step three projects carried out in primary and in secondary schools have been followed. We have chosen to place ourselves in three levels of the general and compulsory education, in a comparative standpoint which characterizes a curricular approach: the third level of primary school, the lower secondary school, the first level of the higher secondary school, in the existing institutional framework. The works presented here are only one of the issues raised in a search package aiming at developing a theoretical framework to think out a “possible curriculum” of the ESD. The highlights of the projects are more particularly defined and interviews are beforehand carried out with the pupils on the basis of volunteerism, and then according to projects. The technique used is this of a semi-directed interview which follows a guideline adapted according to the level of the class and the moment of data collection. The analysis of contents of the students’ speech has helped us to determine three sets of item.Thus, are taken into account, the report to the action, which is central in the strategy established by our work, the relation to the other and the involvement in the social fabric, the relation to the world.

RESULTS

Development of a schema of commitment

The implement of an action of SD requires on the part of the actors some forms of coordination. It results from the special mobilization of external and internal support to the subjects, in a conscious and an unconscious way.
Their inventory and their parameterization (Dodier, 1993)[1] is a necessary prerequisite for any research on this issue. However, supports can become obstacles according to the schemes of coordination desired or desirable: the schemes of coordination are in fact oriented by the missions institutionally prescribed or self-prescribed by the actors themselves. These schemes are dependent on external support, resources and constraints, and internal support to the acting subject.
The internal support exists in the form of a capacity already present but prone to transformation through reflexivity. We assume the presupposition that any experience carried out by an individual develops in him some “dispositions” (E. Bourdieu, 1998). These dispositions constitute the basis which determines the intentions, the choices, the decisions and the way of acting of individuals. But the dispositions are not observable.
In a search for coherence in the references to be used, we look to the pragmatist philosophy. In a postmodern and pragmatist approach, Hans Joas insists on the creativity inherent in “human acting” (1999). Indeed, for Joas, this deep characteristic of human being is revealed in the confrontation with crisis situations. Beyond the speech, it’s about commitment and intentionality which he is talking about. Thus, for this author, thinking of the “human acting” comes to distinguish between intentionality, corporeality, and sociality which for their part are observable. He thus makes distinctions which allow us to think of the intention of commitment and action of the subject. These parameters result for their part of the underlying trends, or “dispositions”, of individuals.
The external supports, for their part, are linked to the situation, the material conditions and institutional realization. In the case of an action of ESD (AESD), those are the effects of territorial, institutional and media (exhibitions, local associations …) contexts. But beyond the support, these contexts affect the whole of the situation through the repercussions that they have on the identity of the actors themselves.
Two extreme forms of coordination are then possible depending on the internal and external supports existing. If the forms of coordination between teachers have been the subject of recent studies (Grangeat and Coquide, 2010), the AESD require the involvement of the whole of the "stakeholders" of the action of SD enterprises (Lange et al, 2010). A term to term correspondence may be established.
The first one is minimalist. It requires only a multilingual and instantaneous comprehension and depends on the situation. In the case of the ESD, it corresponds to the modality of "teaching" and not “educate”, including that of the co-disciplinarité, i.e. an *additive form*. The second one is Maximalist. It’s based on the sharing of judgment of universal value and the need of judgments, or shared "reasoned opinions", deliberations, of arguments, returns on oneself explicit by the language. In the case of the ESD, this extreme form corresponds to what we have designated under the word AEDD. The most sophisticated form, or *co-active form,* is based on two skills of the actors: their capacity to get involved in the coordination and their capacity to adapt to the change of forms. They characterize the establishment of a "learning community" (Kalubi, 2005), and "research community". (Lipman, 2006). Being non-spontaneous, it requires a specific learning.
Between these forms, an intermediate form, called *completive form*, is possible.

[1] Dodier’ s work is based on the work of Boltanski and Thévenot (1990)

The schema below is adapted from a model developed by Godin (1991) from a work carried out in Psycho-sociology about education in health that was reprocessed - with pragmatist references. Unlike the work of Godin, the aim here is not a behavioral change but the commitment of the actors in a collective action of DD. This schema is a synthesis and puts into perspective all the parameters.

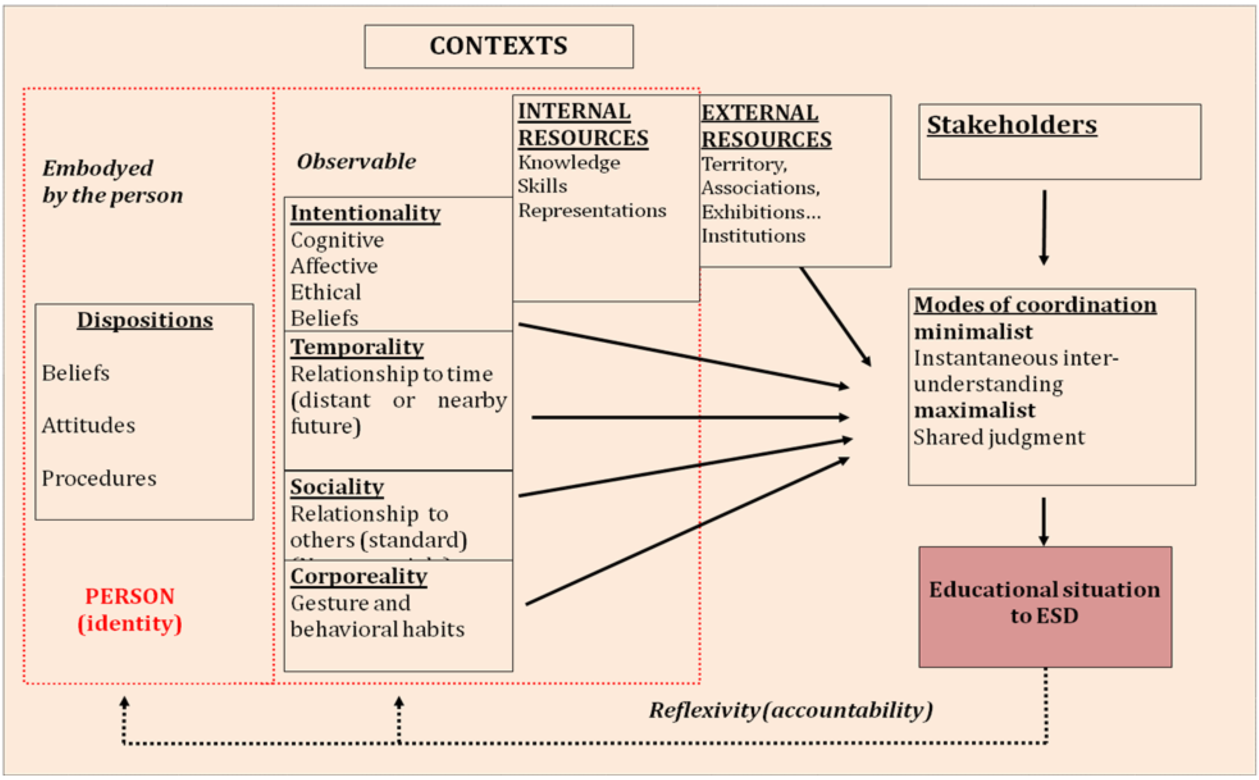

Fig. 1: parameters of engagement

Determination of the indicators

The analysis of contents performed previously allowed us to select a number of items. It constitutes the foundation for the development of qualitative indicators of ESD (Lange et al, 2010). It remained to clarify the relationship between these items and the determinants of the collective commitment in an action of SD to establish indicators. Empirical confrontation to their usage helps us to assess their relevance and efficiency. We propose the following list:

- Indicators of internal resources mobilized by the person
- Relationship to knowledge *(as part of the culture; as a tool for the analysis; such as support for the action)*
- Complex thought and "multireferentiality "*(simple opinion; developed opinion; reasoned opinion)*
- Relationship to Nature *(subject, resource, project)*
- Relationship to science and technology *(rejection, such as a solution (low sustainability); part of the questioning and solutions (strong sustainability))*
- Relationship to the other *(the other as support, the other as obstacle)*
- Skills in real situation

- Indicators of intentionality
- Appropriation of the challenges of the DD. *(convinced active; confident self; responsible)*

- Acceptability at School of the ESD *(rejection; indifference; accession)*
- Acceptance of the constraints *(inhibitory; accepted)*
- Level of participation in the project *(running, participation in exchanges, participation in the development of the project)*
- Level of involvement in the action *(passivity, unreasoned impatience to act ; desire of collective action; in the reasoned action)*

- <u>Indicators of temporality</u>
- Temporality of the proposed action *(immediate, delayed, postponed on other generations)*
- Perception of vulnerability *(naïve catastrophism ; enlightened catastrophism)*
- Appropriation of a spirit of solidarity *(extended to non-humans and to future generations or not)*

- <u>Indicators of sociality</u>
- Ability to perform transfers *(family; territory of proximity; worldwide)*
- Appropriation of the SD as a new social norm

- <u>Indicators of corporeality</u>
- Direct indicators *(actual observed gestures and behaviors)*
- Indirect indicators *(induced effects on consumption, production of waste, usages of devices)*

- <u>Indicators of forms of coordination</u>
- "Additive" form *(ESD in classroom and customary courses)*
- "Completive" form *(Community of practices among teachers)*
- "Co-active" form *(establishment of a learning and research community, focused on the education team, opened to stakeholders)*

OUTLOOK

We now have a schema of the commitment in the action, available to query the situations of education for sustainable development and a set of qualitative and quantitative indicators of the operational efficiency of these actions. Making them operational for the class requires integrating them in the form of an index describing the profile of the student,

We intend to use the idea of "agent", "actor" and "author" mentioned in the literature (Lange et al, 2010). Let's make clear these words by using an analogy adjournment of the didactic of the physical education and sport, a didactic of a creative action, and in particular the work of Mrs. Romain on the dance of creation "dancer, spectator, choreographer". The analogy is based on the fact that an ESD project is a creation without constant renewal in which the teacher masters the intention and the educational aim but in which he knows neither the possible solutions nor the way to perform. They co-construct the whole of the experience. We can distinguish, the "agent" who is behaving like a subject in the school system or a simple performer, the "spectator" who is on the intellectual side of the case; the "activist" who is anxious to act in favor of the SD and the "author" who combines in harmony making and saying, the action and the speech. This profile corresponds to the high ideal expected type, and becomes the referred educational for a curriculum for the ESD.
At this stage, we have a grid of indicators of the operational efficiency of the ESD and are now looking to develop a tool for the actors of the ESD (educators/learners) in the form of synthetic indices, the index, capable to account for the dynamics among the students, and

therefore to accompany them, thus including the actions of SD in an sustainable educational process.

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PONDERING DEBORAH’S DILEMMA: ASSESSING RISK IN SCIENTIFIC ISSUES

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Abstract: Risk has now become a feature of science curricula in many industrialised countries. While risk is conceptualised within different theoretical frameworks the predominant model used in examination specifications in the United Kingdom is a utility model in which risk is deemed to be objective through technical expert assessment, and where the perceptions of individual actors can be corrected by appropriate rationalisation of action and thought. However, research studies on heuristic reasoning and public decision making concerning risk-based issues in science demonstrate that a utility-based approach fails to take into account social, experiential and cultural factors which frame what is considered to be risky. Our research study with science and mathematics teachers deploys a microworld, „Deborah‟s dilemma‟, which presents a decision-making scenario involving probabilistic estimates where teachers construct their personal models of risk. Teachers were recorded in dialogue while working through the microworld. Inductive coding of the dialogue and interactions with the microworld shows that teachers‟ decisions on risk have a rational underpinning but that use of data and information only becomes coherent and comprehensible within the explicated values of decision-makers. We suggest that designing programmes on learning about risk in science must incorporate the opportunity to make values explicit in concert with developing understanding of probability and other factors.

Keywords: Risk, values, curriculum, decision-making

BACKGROUND, FRAMEWORK AND PURPOSE

In 2000, in the wake of crises such as BSE, Chernobyl and salmonella egg poisoning affecting international agriculture and nuclear industries, the House of Lords Science and Society Committee noted that „When science and society cross swords, it is often over the question of risk.‟ (http://www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3806.htm#a37). Such policy responses which have led to arguments for the inclusion of risk assessment and evaluation in U.K. curricula (Millar and Osborne 1998) reflect public anxiety in developments in science and technology in late modern societies in what has become known as the Risk Society (Beck 1992). Risk is now included in the national curriculum in science in England as well as other industrialised countries. While there have been cogent epistemological justifications for the inclusion of risk as a topic in the science curriculum (Ryder 2002, Christensen 2009) and empirical studies on students‟ understanding of risk assessments (Eijklehof 1990, Kolstø 2006, Gardner *et al*. 2010) there has been no developed theoretical framework in science education which draws on the social, cultural and psychological literature underpinning the teaching and learning of risk. Risk is now covered extensively in examination specifications in England where the predominant model of risk is a utility approach. The purpose of our study was to design a decision-making scenario co-ordinating elements of probability and outcome in an authentic event involving risk-based decisions which would enable us to examine experiential and personal constructs of risk.

RATIONALE

If there is such a thing as „actual‟ risk, or a range of situations when objective risk can be depicted, then teaching needs to focus on utility and rational approaches to defining and solving risk problems, which might take into account popular perceptions of certain unlikely events (Slovic 1987). For example, the Salters-Nuffield Advanced Biology textbook (Hall *et al*, 2005) defines risk as „the probability of occurrence of some unwanted event or outcome‟ (p.20) and that „[P]eople frequently get it wrong, underestimating or overestimating risk‟ (p21). Our research involving science and mathematics teachers who would be teaching about risk was to explore how teachers construct concepts of risk and what faculties and domains of experience they draw upon in discussing how to make a decision in an authentic risk-based scenario.

METHODS

We developed a scenario, Deborah‟s Dilemma, in which three pairs of mathematics and science teachers considered the dilemma faced by a fictitious person (Deborah) about whether to have an operation that could cure a spinal condition that was causing her considerable pain. Teachers were encouraged to put themselves in Deborah‟s situation. Having the operation would be likely to result in a complete cure but would entail certain hazards which would need to be discussed by the teachers from various sources of information. Choosing not to have the operation would result in Deborah/the teachers managing her/their lifestyle(s) through daily routines of work, domestic and leisure activity, in order to alleviate the ongoing pain resulting from the medical condition.

Information about Deborah‟s condition was set out within the software <www.riskatioe.org> in a deliberately personal way, to offer different perspectives with varying levels of authority. Two software tools accompany the information about the condition. The first (*Operation Outcomes*)

(Figure 1) is a probability simulator in which the teachers modelled the possible consequences of having the operation. The likelihoods for these various complications (i.e. side effects of the surgery, ranging from minor to serious, and even death) were quoted in the information provided in differing forms and from conflicting, sources. The teachers were required to draw on the sources and decide which possible complications to incorporate into their model with what they considered to be appropriate probabilities of the operation‟s success. Hence the teachers created their own model as an interpretation of the complex information provided.

Figure 1: Probability simulatorOperation Outcomes

The second tool, the *Painometer*, (Figure 2) is a less conventional attempt to give a quantified experience of Deborah's pain and how different activities may cause it to increase and decrease, relative to a “tolerable” level where the personal perception of pain is a potentially interesting context for probing people's personal models of risk. The teachers were required to decide what activities Deborah should or should not do and to infer from the information the effect on Deborah‟s pain level due to those activities.

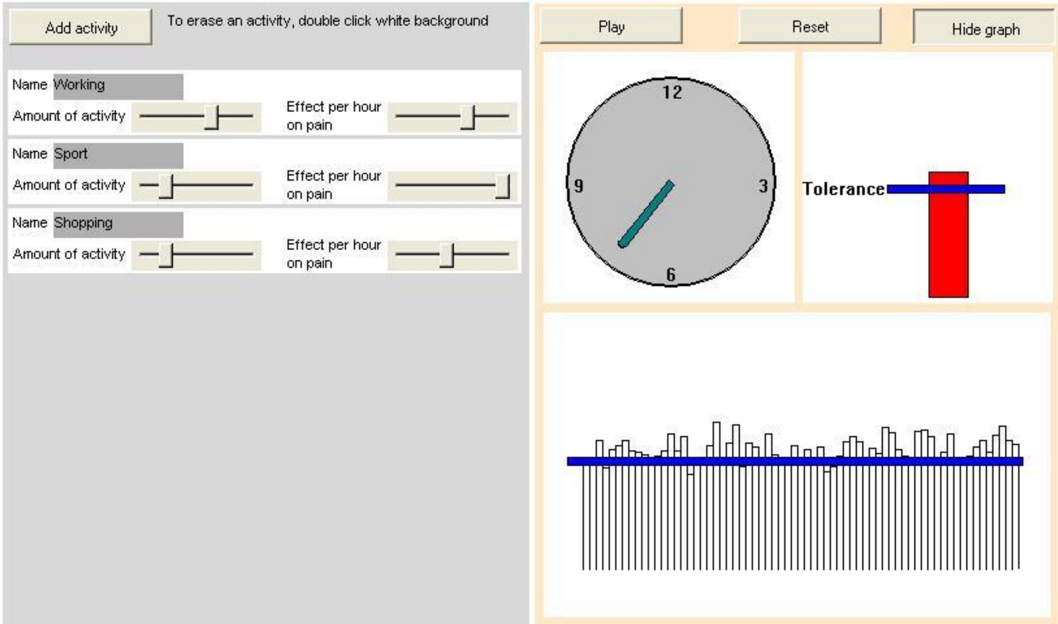

Figure 2: The painometer used to model Deborah‟s lifestyle

The teachers were able to control Deborah‟s level of pain tolerance, the amount of work and domestic/leisure/sport activity that Deborah does and the pain intensiveness of each, assuming that some types of work and sport would worsen the pain and others would relieve it. It was also possible to introduce new activities such as shopping and yoga into the model of lifestyle with the aim of looking to see if a balance could be achieved between pain-inducing and pain-relieving activities, so that Deborah might achieve a tolerable amount of pain from day to day.

The teachers (one science and one mathematics practitioner from the same school in each pair) worked through *Deborah's Dilemma* to consider the options and what decision they might take were they in her shoes. A researcher sat with each group but only intervened to demonstrate relevant aspects of the software, to address any technical points and to ask questions for clarification. Having arrived at a decision, each pair of teachers wrote a report explaining their reasoning. Video screen capture software recorded the process of decision-making through the teachers‟ dialogues and manipulation of the simulators. The session lasted approximately 2 hours. Data for the analysis consists of an audio transcript for each pair of teachers, a video record of their interactions with the software, their written account of the reasoning behind their final decision and notes from each researcher including observations from a „floating‟ researcher who was able to compare the inference-making of each pair. Team members inductively derived themes from the transcripts which were iteratively negotiated.

RESULTS

The following themes emerged from analysis of the transcripts.

i. Five of the six teachers decided that the operation was worth having even though there was a 1 in 200 chance of serious harm resulting from the operation.
ii. All three groups of teachers were critical of sources of data even though they were prepared to make decisions based on probabilities which they were ambivalent about.

iii. Following from ii teachers tended to trust medical/scientific authority even though they realised the source of this data had uncertainties associated with it. While teachers" trust of expert opinion reflects that of students in Kolstø"s work (2006), the difference is that the teachers understood in a sophisticated way the limitations of scientific expertise and the uncertainties associated with it.

iv. Teachers" assessments of risk were made in the context of their personal, experiential and social values which they explicated. Considerations of probabilistic estimates and changes in lifestyle could only be explained and understood in these terms. At best judgments based on probabilities were post hoc rationalisations of value considerations.

v. Teachers provided justified and evidence-based reasoning throughout the decision-making process but their decisions did not necessarily follow from reasons given. Teachers" constructions of their personal models of risk incorporated both rational assessments and values based considerations.

vi. Teachers rarely co-ordinated probabilistic estimates of the operation"s success with changes in lifestyle and did so only on prompting.

CONCLUSIONS AND IMPLICATIONS

Our analysis suggests that the utility approach to teaching risk provides only a partial understanding of the social and individual complexities involved in making risk-based decisions. Two pedagogic implications emerge from our work: a. while an understanding of probability might aid making risk assessments this presupposes values explication. This is a crucial challenge for teachers but one that pupils are likely to respond to. b. Co-ordinating probability with considerations of impact or alternative courses of action needs to be made explicit in any teaching and learning model of risk. We have therefore incorporated a feature in the Deborah"s Dilemma microworld which allows this co-ordination to take place.

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TURKISH SECONDARY SCHOOL STUDENTS' VIEWS ON SOCIO-SCIENTIFIC ISSUES: RESOLUTION REQUIRES ACTION

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Abstract: This study examines Turkish secondary school students' informal reasoning in the context of responding to three dilemmas on socio-scientific issues (SSI). A qualitative methodology was adopted to attain a deeper understanding of the students' informal reasoning. Data collection involved having the students respond in writing to two of the three dilemmas followed by group interviews. The participants were 36 students (22 male, 14 female) at grade 10 (age 16). Data were analyzed using constant comparative method to identify themes in the participants' arguments. The emerged themes were action, agents of, types of, reasons for, and the tone or attitudes towards action. Most of the students lacked scientific knowledge on the SSI dilemmas, yet considered the dilemmas not as technical but as ethical problems, having their roots in human nature, manifested by the actions of individuals and governments. The students viewed human nature as extremely individualistic and hence must be regulated by a higher authority such as the government. For the students, individuals and governments are not sincere in their efforts related to SSI, leading to doubt; human nature will not change, leading to despair about the possibility of solving the SSI dilemmas. The results imply that students do not need huge amounts of scientific or philosophical knowledge to engage in SSI discussions. The results also imply that for science education it may be meaningful to focus not solely on epistemology but also on ethics and politics as well.

Keywords: Socio-scientific issues, global warming, Turkish secondary students

BACKGROUND, RATIONALE, AND PURPOSE

Preparing scientifically literate citizens who are able to participate in decisions is stated as one of the major goals of science education (OECD, 1999). The class of decisions that await citizens such as genetically modified food, energy choices, and managing natural resources are called socio-scientific issues (SSI), which are often controversial, ill-structured, and lack clear-cut solutions (Sadler, 2004). Reasoning about SSI, often conceptualized as informal reasoning, usually involves making value judgments by coordinating scientific knowledge with ethical and personal concerns (Sadler & Zeidler, 2004) as well as by considering economic, political, legal, or religious factors (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007). Based on the nature of informal reasoning, it is reasonable to expect that value judgments and personal considerations are influenced by the society and hence vary from one cultural context to another. However, much of the science education research about informal reasoning has been conducted in Western Europe (Ekborg, 2008; Lewis & Leach, 2006) and the USA (Barab et al., 2007; Sadler & Zeidler, 2004). Few studies have explored informal reasoning in the context of SSI in a developing country such as Turkey.

Studies in Australia (Boyes, Skamp, & Stanisstreet, 2009), Spain (Rodrigues, Boyes, & Stanisstreet, 2010), and Turkey (Kilinc, Boyes, & Stanisstreet, 2011) with secondary students on global warming and energy issues were mostly concerned with individuals' beliefs about usefulness of specific pro-environmental actions and their willingness to undertake those actions. For direct actions such as paying more for low energy appliances the willingness to act was more than the belief in usefulness of the action for all three countries. On the other hand, for direct actions such as paying more for electricity generated in nuclear power stations and using public transportation, and for indirect actions such as voting for environmental taxes, legislation, or international cooperation, the belief in usefulness of action was more than the willingness to act. These results were interpreted by the perceived cost of the disincentives and the benefit of the incentives: when there are incentives, such as spending less on your electricity bill and the disincentives are of small inconvenience, the students expressed that they were willing to take action; when the incentives are not that important, and the disincentives are of considerable inconvenience students were not willing to act. However, because the research was based on close ended instruments the reasons for the willingness to act was not explored. Similarly, it is possible that students do not understand the consequences of taking or failing to take pro-environmental actions. For example, Andersson and Wallin (2000) found that 15 year old Swedish students supported a drastic reduction in carbon dioxide emissions, but failed to understand the fundamental social impact of it. Students views on the ethical and political aspects involved in SSI remain to be explored.

The purpose of this study was to explore Turkish secondary students' views on SSI and the reasons for holding those views in the context of responding to SSI dilemmas. With this purpose, this study focuses on the content of the students' arguments, not on their form.

METHODS

The Research Setting and the Sample

Until 2010 students in Turkey were making the transition from primary to secondary education based on the results of a series of central standardized exams called Level Determination Exams (SBS) that students take at the end of the grades 6, 7 and 8. About one million students were entering the SBS every year and were placed to various secondary education institutions according to the ranking of their exam scores (MoNE, 2007). The secondary schools in demand are usually described by the percentile ranks of their students in SBS. The school that this study was conducted was in Istanbul and accepted students whose ranks were above the top 5% at the SBS for the year 2010 (MoNE, 2010). The school's achievement in transition to higher education is high; 80% of the graduates of 2010 were placed in a higher education institution. In the school the cohort of grade 10 (age 16) students had about 120 students in four classes. The teachers and administrators in the school stated that the classes at grade 10 were similar in terms of achievement, which was taken as an indicator for the homogeneity of the group in addition to the students' SBS scores. Two of the four classes were selected, from which 36 students (22 male, 14 female) volunteered to participate in the study. Although these selection issues suggest that the results should be interpreted with caution for generalizing to the population of all students in Turkey, they also match the requirements for the purposeful sampling for this study which seek to understand the views of high achieving students who are also articulate about expressing their views on SSI.

Data Collection and Analysis

To attain in-depth understanding the data was collected through a writing task involving three SSI dilemmas followed by group interviews. The SSI dilemmas were about energy crisis, global warming, and water taxation. The participants were given 90 minutes to respond in writing to two of the three dilemmas. Afterwards, the participants were grouped with respect to the dilemmas they have answered, and nine groups of four participants were formed for interviewing. The group interviews were conducted in a quiet room at the students' school and mediated by two researchers, with the dual purposes of giving the participants a chance to clarify their written responses and to interact with the other participants. Each group interview session lasted about 40 minutes, audio and video recorded, and was transcribed verbatim for further analysis. During the group interviews the participants were given back their written responses, then for each dilemma they summarized their ideas, and then the participants talked to each other, discussing, asking questions, challenging, or supporting others' arguments. The researchers also contributed to the discussions by asking clarifying questions when appropriate.

The data analyses involved cyclic processes of data reduction, data display, and conclusion drawing/verification, which are characteristics of qualitative analysis (Miles and Huberman, 1994). All transcripts were imported to the qualitative analysis software ATLAS.ti to manage and organize the data as well as to keep track of the analytic progress. Data was reduced by coding in which the bulk of the dataset was condensed into analyzable units by creating categories from the data utilizing constant comparative method (Glasser and Strauss, 1967). The transcripts were read line by line and open coded independently by the two researchers, and then these open codes were compared and discussed. Overlapping codes were identified, and similar codes were merged under common names, and finally the open codes were structured around general categories. The criteria for validity for the analysis were based on convergence, agreement, and coverage by the researchers (Gee and Green, 1998). The resulting conceptual themes were derived with the consensus of the researchers.

RESULTS

As the result of the data analysis, the following themes emerged: action, agents of, types of, means of, and reasons for action, and the tone or attitudes towards action (see Figure 1).

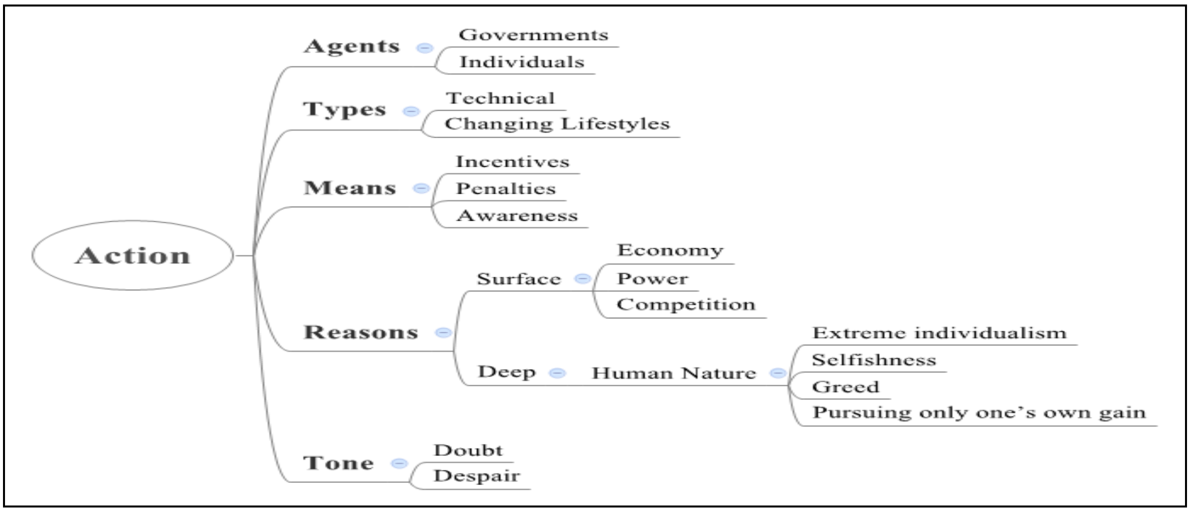

Figure 1. Themes emerged in the context of the SSI dilemmas.

Most of the students stated that they did not possess adequate scientific knowledge about the SSI dilemmas. Nevertheless, the students responded to the SSI dilemmas either positively, signifying that the dilemmas could be resolved, or negatively, suggesting that the dilemmas could not be resolved. In either case, resolution or lack of it was determined solely by acting or failing to act. For instance, according to the students the resolution of the global warming problem depended solely on the governments deciding to reduce carbon dioxide emissions and acting resolutely on these decisions. However, most of the students said that such a decision was not likely and hence it will not be acted on.

Agents of action

According to the students, the required actions for resolving the SSI dilemmas would have to be taken by governments or individuals. The majority of the students stated that individual actors could not change the world; it was mainly the governments' responsibility to take action for the SSI which they often failed. For instance, some students argued that regulating water consumption was beyond the individual and the government must act and intervene with water consumption by passing a water tax bill. The students who said that individuals may have some influence on reduction of water consumption, nevertheless, expressed that the water consumption issue cannot be resolved solely by individual efforts but by the government's action, educating the citizens, launching advertisement campaigns for water conservation, or encouraging the citizens to adopt new technologies that reduce water consumption by offering incentives.

Types of action

According to the students, there could be two types of action for resolving the SSI dilemmas: interpreting the problem as a technical one, it could be developing new technology or perpetuating existing technologies; or interpreting the problem essentially an ethical one, it could be changing people's ways of living. For instance, some students stated that the energy crisis could be resolved by developing new energy technologies that provide clean and abundant power. Other students who thought that the energy crisis is an essentially ethical problem and not a technical one argued that the resolution was independent of the amount of available energy, resolution can only be possible through fair distribution of energy, only if people are thoughtful about not only themselves but others as well, and wanted to share the resources they have with others in a just way. According to these students, the resolution was only possible by a profound change in ethical considerations and also by adopting a new lifestyle based on sharing responsibility towards all people on Earth. However, these students did not find it likely; the countries that are rich in energy resources would not agree to share their resources with other countries.

Means of action

The students suggested three ways as means for action including providing incentives, enforcing penalties, and creating awareness in relation to both types (technical and lifestyle changes) of action. The incentives could be in the form of tax reduction or exemption, low or no interest loans, or some other benefit for the people to adopt new technologies or change their lifestyles. The penalties are often stated as monetary fines, but some students also offered further sanctions including imprisonment, depending on the issue at hand. One of the common measures that the students offered as a means of action in the context of the water taxation issue was introducing a fine for overconsumption. Creating awareness in the public required providing explanations for the rationale behind the proposed actions and the possible benefits for the people. Some of the students offered education and especially voluntary participation in education as a way of creating awareness. Reflecting on their own experiences, some students said that they have changed the ways they behaved after participating in educational events such as conferences. However, some students objected to the possibility of changing people with education, according to these students it was mainly a person's conscience that guided her behavior of complying with the proposed measures for resolving the SSI.

Reasons for action or no action

According to the students, there were two classes of reasons, surface and deep reasons, for the governments and individuals taking or failing to take action. 'Surface reasons' refer to the arguments for actions at societal, governmental, or intergovernmental levels. Fear of an economic crisis, the race for power, and competition for resources are stated as the surface reasons. For example, on the surface reasons behind the lack of taking action for global warming a student said:

> The developing countries are actually acting rational when you look from their perspective; they should not listen to it. Because when these countries reduce the carbon dioxide emissions they will fall behind. (G9.S03).

'Deep reasons', the underlying reasons, essentially articulated as extreme individualism, stem from immutable traits of human nature, manifested by selfishness, greed, and pursuing only one's own gain. Human nature does not allow for action not in favour of one's own gain, unless the peril is immediate. Therefore, the SSI dilemmas essentially cannot be resolved, unless individuals and their human nature are regulated by a higher authority such as the government. For example, on deep reasons underlying the global warming issue during a group discussion some students said:

> S31: This one is also selfishness. The very same thing with the energy crisis.
>
> S17: Because people are the same. Everyone only thinks about himself. They should think about the human race. But it just isn't like that, people are selfish. If they keep acting like this there won't be a solution. We can never solve this problem.
>
> S17: They have been living like this for centuries. They will never change (G4).

Tone or attitude towards action

The general tone of the students' writing and talk on the SSI dilemmas was marked by either doubt or despair. The students did not seem to believe that the governments and individuals were sincere in the efforts for taking action to resolve the SSI dilemmas. The students thought that individuals' decisions and actions could not contribute so much to resolve the SSI dilemmas and the governments always had hidden agendas, hence these students expressed that they doubted that SSI dilemmas could ever be resolved. Similarly, some of the students appeared to have completely lost faith for even the possibility of resolving the SSI dilemmas. According to them, governments and individuals were self-serving, greedy, did not genuinely care about, and lacked the will for resolving these issues. Out of despair, these students suggested that a war would be the solution:

> Interviewer: What if we assume that there has been a really big war. What would happen after the war?
>
> S06: Another war would break out. The developed countries won't be content with it. With their historical exploitative personalities they will want to do the same thing.
>
> S30: If people were actually humans then they might have changed for the better.
>
> S10: But I don't think that is likely (G1).

DISCUSSION

Most of the students considered the SSI dilemmas not as technical but as ethical problems, having their roots in human nature, manifested by the actions of individuals and governments. The students viewed human nature as extremely individualistic and hence must be regulated by a higher authority such as the government. For the students, individuals and governments are not sincere in their efforts related to SSI, leading to doubt; human nature will not change, leading to despair about the possibility of solving the SSI dilemmas. The results expand the cost-benefit analysis explanation for the lack of willingness to take environmental action (Boyes et al, 2009; Chokkar et al., 2011; Kilinc et al., 2011; Rodrigues et al., 2010) and are contrary to that students do not understand the fundamental social impact of undertaking environmental actions (Andersson & Wallin, 2000).

Such a dark point of view from teenagers is alarming. The students do not view themselves as active agents, who can change the state of affairs in the world, hence are not only indifferent about taking pro-environmental action but they consider it as futile. Perceiving that all solution possibilities are in the hands of governments and believing that governments cannot be trusted, they appear to be paralyzed. These results may have cultural explanations, for example, Turkey is becoming a modern democracy but the relative positions of the individual and the state still is quite behind the ideal, which may account for the students' perception of themselves as passive rather than active agents on issues that involve pro-environmental action. Similarly the students may not be trusting to the government because they perceive the government as corrupt. Finally, the students' perception of the Western countries as having great power on international decisions but pursuing only their own benefit may be another explanation.

On the positive side, perhaps not on an individual basis, but the students' collective arguments on the SSI dilemmas seem quite sophisticated. Although the sample consisted of academically talented students, it still is striking that these 16 year olds tackled major philosophical questions about ethics, human nature, individualism versus collectivism, and the problems facing the world. The students lacked scientific knowledge on the SSI dilemmas and there is reason to doubt that they had any philosophical training. Yet, the students were able to capture and argue on these ethical and philosophical issues and their relations to the SSI dilemmas. Previous research (Lewis & Leach, 2006; Ekborg, 2008) already showed that students do not need huge amounts of scientific knowledge to discuss SSI, the current study confirms these results and extend it to philosophical and ethical knowledge; students, in the very least the academically talented, probably do not need huge amounts of philosophical knowledge to engage in SSI discussions. The results also imply that it may be meaningful to focus not solely on epistemology but also on ethics and politics. However, studies with representative samples are required in Turkey and other countries.

NOTES

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INVESTIGATION OF PRIMARY SCHOOL STUDENTS' ATTITUDES TOWARDS TECHNOLOGY

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Abstract: In this study, it is aimed to determine whether primary school students' attitudes towards technology vary by students' gender, their grades, family income levels and also socio-economic levels of the schools they have studied in. According to the "appropriate sampling" method, 882 students from 6th, 7th and 8th grades in 9 primary schools are included in the study. The Turkish version of Pupils' Attitude towards Technology (PATT-TR) scale which was adapted to Turkish by Yurdugul and Askar (2008) was used in this study. In data analysis, "SPSS 16 Statistical Package Program" was used. According to the results of the study, there was no significant difference between students' attitude scores in terms of their gender. In addition, significant differences were found in students' attitude scores in terms of students' schools, grade levels and their families' income levels. Differences identified in attitude scores of students were found in favor of 6th grade students, the children of middle-level income families, and again students of the schools close to the middle-level socio-economic levels.

Key words: Attitude towards Technology, Primary School, Students, Science and Technology Literacy.

1. INTRODUCTION

One of the most effective elements of the information age, the use of technology does not only make the individual, community and member of a profession more powerful and life-facilitating against events and facts but also imposes new responsibilities the individual, community and member of a profession. It is an undeniable fact that the individual, community and member of a profession who is aware of these responsibilities, who can produce and use technology and who is integrated with technology is always better to be ahead and more powerful (Kısa & Kaya, 2006). In addition, the number of people who state that the use of technology in schools increases student achievement is more than the number of people who say that the use of technology is a waste of time and money (Bransford, Brown & Cocking, 1999). Widespread use of technology at a great pace in the field of education brings the issue of how much technology, due to its positive effects on student achievement, should be included in education programs to the fore. Balcı and Esme (2001) have stated the causes of why technology should be in public education programs respectively; i) education cannot be considered separate from contemporary life and technology, ii) technology increases the creative capacity by developing the critical attitude, iii) technology contributes to the development of intelligence and competence, iv) technology education complements other courses, v) as a result of technology education, no matter when students leave the school, they can be adapted to the technical life they live in. In addition to this, social, political and economic developments in society in parallel with attitudes, needs and values of people are also highly influenced by technology (SSC, 1989). In this context, students' attitudes towards technology and containing technology in science and technology lessons are important.

1.1. Rationale

Since the second half of the 20th century, "understanding of the interaction between science, technology and society" began to gain importance in the field of education. In this context, it is seen that new regulations are brought to science education and scientific literacy to eliminate the problems related to health, natural environment, communication, energy resources, food resources (NRC, 1996). One of the dimensions of scientific literacy, considered as one of the most important goals of modern science education, is an individual's understanding technology and the mutual interaction of technology with science and society (AAAS, 1993; NRC, 1996; Bauer, 1996; Hughes, 1997; Hurd, 1998; Murphy et al., 2001). In this context, it is important to investigate students' attitudes towards technology to let them develop positive attitudes towards technology and understand the nature of science and technology. In this regard, primary school students' attitudes towards technology were investigated in the study in terms of their gender, grade level, family income level and socio-economic levels of schools.

2. METHODOLOGY OF THE STUDY

2.1. Methods

In this study, the survey method was used to investigate the primary school students' attitudes towards technology in terms of demographic variables. The study was performed in the 2009-2010 academic year in the province of Burdur which showed a very high success in high school and university entrance examinations in Turkey.

2.2. Participant

According to the "appropriate sampling" method, 9 of 34 primary schools could be applied an attitude scale. The study sample is consisted of 882 students studying in the 6th, 7th and 8th grades in 9 different primary schools representing lower, middle and upper socio-economic levels.

2.3. Data Collection Tool

"Turkish version of Pupils' Attitude towards Technology (PATT-TR)" scale was used in this study. The scale of Pupils' Attitudes towards Technology (PATT) is a scale developed by Marc de Vries (1988) within the "Students' Attitudes towards Technology" project. In addition, PATT scale is applied in more than 25 countries from the year 2002 (Volk & Ming, 1999) and findings are described in various publications or PATT conferences (cited in Yurdugul & Askar, 2008). Yurdugul and Askar (2008) adapted the PATT scale to Turkish language by carrying out validity and reliability studies. Researchers was found that PATT-TR scale consisting of 24 items have a high item-consistency (ω=.92). The scale is a 5 likert-type scale consisted of four sub-dimensions which are "Tendency to technology", "Negativeness of technology", "Importance of technology" and "Technology for all".

2.4. Data analysis

In order to analyze the data, answers of the students who participated in the study are scored from 1 up to 5 in accordance with 5 Likert-type scale. The total score of attitude towards technology obtained from each student was analyzed using "SPSS 16 Statistical Program". To determine the effect of gender variable on students' attitudes towards technology, “Independent t-test” was used; for the analysis of factors such as grade level, family income and the school’s socio-economic level, the "One Way ANOVA -Post Hoc Tukey HSD" tests were used.

3. RESULTS

In the study, maximum score that students can achieve in the survey of attitudes towards technology is 120 and the minimum score is 24. Students’ mean attitude scores towards technology and other descriptive statistics results have been given in Table 1.

Table 1. *Descriptive statistics results of students’ attitudes towards technology scores*

N	$\overline{X}$	Min.	Max.	SD	Med.	Mod.
882	89,05	39,00	120,00	15,064	90,00	81,00

As can be seen in Table 1., primary school students' scores of the attitudes towards technology was found to be normally distributed. Students obtained a minimum 39 point, and they have obtained a maximum 120 mean attitude point from the scale. In addition, the overall mean score was calculated as 89.05 point. In this context, students’ attitudes towards technology were found to be in positive level. Also, according to likert- type scale, this mean score matches to (3,71 ≅ 4,00; agree) medium level.

Table 2. *Results of the Independent t-test on the mean attitudes scores of students according to gender factor*

Gender	*N*	$\overline{X}$	*SD*	*t*	*p*
Female	436	88,52	14,824	-1,036	,300
Male	446	89,57	15,294		

When students’ attitude scores were evaluated in terms of gender variable, mean attitude score of the female students towards technology was found to be $\overline{x}$=88,52 and that of the male students was found to be $\overline{x}$=89,57. According to analysis, a significant difference was not found between male and female students’ mean scores of attitudes towards technology (p>.05). Also both male and female students have positive and medium level of attitudes towards technology.

Students’ attitudes towards technology were examined in 3 class level and whether students’ attitudes towards technology differ according to grade or not were analyzed by One Way ANOVA test. Results of the students’ attitude scores have been given in Table 3.

Table 3. *Arithmetic Average of the Students' Attitude Scores According to Their Class Levels*

Class Level	N	$\overline{x}$	SD	F	p
6th grade	314	90,64	14,702	3,315	,037
7th grade	295	88,81	14,429		
8th grade	273	87,47	15,992		
Total	882	89,05	15,064		

Considering the mean scores of attitude towards technology of students, it is seen that the students of 6th grade have the highest mean scores of attitude $\overline{x}$ = 90,64 and 8th grade have the lowest mean scores of attitude $\overline{x}$ = 87,47. When the standard deviations are considered, 8th grade students' attitude scores are in a wide range than 6th grade students. It was found that students' attitudes towards technology differ in their class levels (F(2.879)=3.315), p< ,00). Also according to Post-Hoc Tukey analysis a significant difference was found between scores of the 6th and 8th grade students and it was seen that this difference was in favor of the 6th grades.

The names of the schools included in the present study were coded as S1, S2,… S9. The order followed in the coding of the schools is based on the locations and average economic status of the schools. 9 primary school students' attitudes scores of technology were investigated according to their schools' socio economic status. Results of the students' attitude scores according to their schools' socio economic status have been given in Table 4.

Table 4. *Arithmetic Average of the Students' Attitude Scores According to Their Schools*

Primary Schools	N	$\overline{x}$	SD	F	p
S1	106	86,43	15,597	3,439	,001
S2	152	88,02	17,188		
S3	108	90,44	15,284		
S4	113	91,71	12,791		
S5	110	85,78	14,315		
S6	54	94,96	14,242		
S7	101	90,90	13,281		
S8	59	90,27	16,644		
S9	79	86,04	13,180		
Total	882	89,05	15,064		

According to the results of One Way ANOVA, a significant difference was found between students' attitude scores in terms of their school's socio-economic status (F(8.873)=3.439; p<.05). When students' attitude scores are compared with Post Hoc Tukey test according to socio-economic status of schools; a significant difference was found between students whose school's socio-economic level is close to the middle level (S6) and 3 primary schools students whose schools' socio-economic status are very high (S1), medium (S5) and very low (S9). When the eta square value (η^2= .03) is considered, it can be said that the schools' socio economic status variable has small effect on students' attitudes towards technology.

Whether students' attitudes towards technology differ according to their families' income levels or not were examined by using One Way ANOVA test in 4 groups of income levels. The groups of income levels and the results of the analysis have been given in Table 5.

Table 5. *Results of the Students' Attitudes Scores according to Their Families' Income Levels*

Families Income Levels		N	$\overline{x}$	SD	F	p
00TL - 499TL	(a)	168	87,95	15,545		
500TL- 999TL	(b)	245	89,71	14,837		
1.000TL- 1.499TL	(c)	248	91,13	13,887	3,678	,012
1500TL - +++TL	(d)	221	86,81	15,918		
Total		882	89,05	15,064		

As can be seen in Table 5., while the mean income level of the families of the students having the highest attitude scores was found to be between c TL (Turkish Liras), that of the families of the students with the lowest attitude scores was found to be d TL ($\overline{x}$= 74.34). Moreover, according to income level of families, it was found that a significant difference among the students attitude scores (F (3.878)=3.678), p< .05). According the Post Hoc Tukey HSD analysis significant difference was determined between the scores of students which are c TL and d TL income level in c TL favor. This difference was favor of the students of the families with medium income level. When the eta square value (η^2= .012) is considered, it can be said that the families' income level variable has subtle effect on students' attitudes towards technology.

CONCLUSIONS AND IMPLICATIONS

According to our study, there is no differentiation between female and male students' attitudes towards technology. This shows that gender is not a factor affecting attitude towards technology. In parallel, Köse and Gezer (2006) have indicated that there is no difference found between the gender of students and their attitudes towards computer technology. In addition, while some studies (Loyd, Loyd, & Gressard, 1987; Ray, Sormunen & Harris, 1999) talk about females' attitudes being more positive than males', some (Whitley, 1997; Bame & Dugger, 1989) talk about males' having more positive attitudes. In addition, students' attitudes towards technology are affected by students' grade levels. In this regard, the lower levels can be said to be in a more positive attitude than higher levels. In addition, in terms of the income levels of families, attitudes of children towards technology whose families have moderate-level of income are found to be more positive. In parallel, considering the socio-economic levels of schools, students in primary schools whose socio-economic status is in middle level can be said to have more positive attitudes towards technology than schools whose socio-economic status is in other levels.

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A FRAMEWORK FOR CONSIDERING CROSS-CULTURAL EXCHANGES AS A WAY TO DEVELOP REASONING ABOUT ENVIRONMENTAL SOCIOSCIENTIFIC ISSUES

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Abstract: This study analyses the evolution of socioscientific reasoning on sustainability, of French and Australian tertiary students exchanging ideas on a digital platform, concerning local (Australian, French) environmental SSIs, and global environmental SSIs. We explore how the exchange of arguments from various disciplinary and cultural perspectives, can promote reasoning about complex problem-situations in the environment. We develop a framework of reasoning, and show how it enables a productive analysis of the nature of the exchanges, and the quality of reasoning. We argue that such a strategy may improve epistemological training on the nature of science, and citizenship.

Keywords: Socioscientific issues, Reasoning, Sustainability, Cross-cultural, Digital environment

Teaching Socioscientific Issues (SSIs), at a time when scientific expertise is the subject of controversy and debate in society, places risk and uncertainty at the heart of the teaching / learning process. The very nature of SSIs implies argument about them from different domains of reference (in experimental science, humanities and social science) and from social and professional knowledge. We are interested in this study to explore the evolution of students' reasoning about Environmental SSIs (ESSIs), that is to say problem-situations involving tension between the functioning of ecosystems and human interventions related to the management of these ecosystems' products and services.

1. RATIONALE

Awareness of environmental issues in discussions on the appropriate development model for our society is integrated in educational settings linked to sustainable development. Too often, the educational goal is limited to development of good practice (sort waste, carpool ...). We believe that Education for Sustainability (EfS) can also effect change in students' relationship with scientific knowledge, with the assessment of expertise and with the social relations that are involved. EfS thus implies a scientific literacy questioning the relationship between techno-scientific progress and society.

To address ESSIs from different perspectives, through the prism of various and sometime conflicting interests, seems a good way to understand their complex nature. By bringing together students from different scientific disciplines, and from different continents, we explore how the exchange of arguments from various perspectives promotes the perception of complex problem-situations in the environment. We explore how such a strategy may improve epistemological training on the nature of science, and on citizenship.

To reflect the interactive nature of the exchanges, we chose to use categorizations developed by Mercer (1995) from an analysis of linguistic interactions between students. One of the functions of language, according to Vygostski (1985), is to enable learners to organize their own thoughts and give meaning to words. Indeed, Mercer (2002) states that we use language to transform our thinking through individual thought and collective action. Postmodern thought states that any discourse can only be relative because our era has shown that we cannot establish universal standards. With the Theory of Communicative Action (1987) Habermas shows instead that the communicative function can break this deadlock and produce a democratic agreement. Construction of reason passes in effect through intersubjectivity, with communicative action based on mutual understanding, designed for justice more than truth, to coordinate planned actions.

2. METHODS AND RESEARCH QUESTION

We have posed three ESSIs to Australian and French students who were able to meet virtually through a digital platform. We are looking at the possibilities of on-line community interactions contributing to learning and at the aspects of cross cultural interactions which act to broaden students' perspectives on SSIs. The three ESSIs fit into the general theme of "Feeding humanity." We have chosen this theme for its potential to promote individual and collective reflection on the role of expertise in developing a position. Everyone can feel concerned: as a consumer embedded in his social group, as a scientific expert holding more or less current knowledge, or as a "world citizen" involved in a debate on the future.

Our research question is: How do socio-cognitive disturbances, made possible by this cross-cultural approach, contribute to the evolution of socio scientific reasoning in the perspective of sustainability?

2.1 Design of the intervention

The intervention took place during the months of March to June 2011, with thirteen French students from ENFA of Toulouse in their fourth year of a teacher education degree in different disciplines (animal or vegetal production, economy, sociocultural education) and five Australian students which were undertaking their third year of a teacher education degree and specialized in science and environmental education. The two student groups were each divided into three subgroups, each of which took responsibility for discussion and construction of a wiki on one of three socio-scientific sustainability issues. These three issues were designed such that one issue was particularly pertinent to France (4 French & 1 Australian students), one to Australia (4 French & 2 Australian students), and the third was global in nature (5 French & 2 Australian students). The issues involved :

- A green algae outbreak along the coast of Brittany, linked to release of fertilizer by agronomists. The issue thus involved, ostensibly, a conflict of interest between the enjoyment by citizens of the coastal environment, and the needs of the farming community. The issue had a strong 'local' French context but for the Australian students was 'remote'.

- The construction of desalination plants to produce fresh water. This issue was particularly pertinent, and 'local' for the Australian students since following years of drought the Victorian government had commissioned such a plant, against widespread opposition by rural and environmental groups, and taxpayer interests.
- The consumption of meat, which was held to be an issue of global scale, and similar in exposure to the French and Australian students.

The sequence of events was as follows: A media file was prepared for each of the three issues, and uploaded onto the project website. "Forum A" involved discussion separately for the French and Australians. This took place in the groups' first language and led to the construction of a first Wiki by each group, in English. Then the wikis of the French and Australian groups were opened to each other, and a "Forum B" was opened for international exchanges in which each group questioned the other and attempted to come to a common understanding. The last step was the reconstruction of the wikis following this international exchange.

2.2 Analysis framework

Several researchers have developed and modified a grid to analyse socioscientific reasoning (Sadler, Barab & Scott, 2007; Simonneaux & Simonneaux, 2009, Morin & Simonneaux, 2010) to identify the inclusion of uncertainty and complexity in reasoning about problem-situations. The latest version of this grid from the perspective of sustainability (Socioscientific Reasoning and Sustainability: SSR and S) consists of 6 dimensions (Problematization, Scales, Knowledge, Uncertainty, Values, and Regulation). On each dimension 4 levels of depth are defined, through which the level of reasoning can be assessed.

Mercer (1995, 2002) defined three types of discourse: Disputational talk, where the relationship is competitive, differences of opinion are stressed rather than resolved, and the general orientation is defensive. Cumulative talk, where ideas and information are shared rather than discussed in the process of constructing knowledge. Exploratory talk, during which speakers engage in critical but constructive discussion about each other's ideas and alternative viewpoints are suggested. Most studies show by analyzing the language of students during classroom debates that there are mainly disputational and cumulative talks. A number of limitations have been attributed to Mercer's approach, in particular because it doesn't take into account the content of speech. This is why we have added another criterion of analysis, concerning the domain of validity of arguments.

Habermas distinguished between for types of social-interactions according to the domains of validity of arguments in reference to the three dimensions of what he called "real life". We have used this reference to the three worlds to characterize on-line community interactions. In the Objective world, statements or questions are based on logic, empirical efficiency, and scientific truth. In the Social world, interventions enable the speaker to show he is a member of a group by following social norms of behavior, or to question the interactions and regulatory procedures between social actors. In the Subjective world, the speaker expresses his/her personal experiences, his/her affect, his/her own perception of the situation, and considers the views and the subjectivity of his/her interlocutors.

Thus, we have drawn up a tool combining these two theoretical dimensions. According to our research question, the analysis is focused on the differences between the type of contributions before and after the opening of international exchanges.

3. RESULTS

On our design work, we observe a lot of cumulative talks, in which reasoning was supposed pre-existing and individual positions already determined. Two other types of talk have been observed. In both, the participant's position is not predetermined: i) in the third type, participation is directed towards the development of individual reasoning, just as in the exploratory talk of Mercer, ii) in the last type, that we have called " Inte gr ati ve talk ",
participation aims at integrating new features into the collective reasoning.

	Cumulative talk	**Exploratory talk**	**Integrative talk**
Reference to the objective world	EXPOSURE The response is affirmative and is based on logic, empirical efficiency, scientific truth. Knowledge is presented as certain. Rationality is technical, instrumental.	REFLECTION The contributions point to differences in statements, doubts, judgments on consistency with the positions of the speaker. The search for new knowledge may be considered.	DISCUSSION Participation is an exploration of the conditions of validity of knowledge on which controversies may be resolved. Rationality is critical.
Reference to the social world	IDENTIFICATION The procedure allows the speaker to show membership in a group. The statements are based on the values of this social group.	RECOGNITION The contribution considers the views of other participants or the views of several categories of social actors. The speaker can ask questions of other participants.	CONFRONTATION Participation is a weighing of different expressions of the interests of stakeholders. The speaker discusses social choices, and regulatory procedures between the categories of social actors.
Reference to the subjective world	TESTIMONY The response expresses the opinion of the speaker, which refers to personal experience. He expresses his emotion, his own perception of risk, or the values underlying personal commitment.	ASSESSMENT The contribution considers views different from those of the speaker, which identifies the values taken by others. The speaker can make judgments, but changes of opinion are possible.	DELIBERATION Participation considers what may be conflicts of values and discusses the principles at stake. The differences are acknowledged and can allow the emergence of new judgment criteria.

Table 1 : Analysis framework

3.1 Impact of contextualizing ESSIs

With the **GREEN ALGAE issue**, it seems that the significance of individual experience is decisive. The introduction of the French wiki gives a sense of the tone: "*I remember swimming and fishing near the river, this was a very important place where every child went after school. I remember when on Sundays we went with my family to the sea smelling the good air and seeing the beautiful landscape. It was few years ago... "*. It is possible for personal commitments to overshadow a more dispassionate consideration of the different interests at stake and the wider social policy ramifications. During the exchanges about this issue, the participations often remained as testimony. Table 2 gives the analysis of these first phase exchanges:

	Cumulative	Exploratory	Integrating
Objective	4	1	1
Social	1	3	
Subjective	4	2	

Table 2: Green algae, French discussions in the first phase, March 14 to May 19 (16 entries)

In the second phase, we collected only a few international exchanges. Most of the discussions are of the cumulative type:

	Cumulative	Exploratory	Integrating
Objective	1		
Social	2	1	
Subjective	4	1	

Table 3: Green algae, international exchanges, May 29 to June 15 (9 entries)

With the **SEAWATER DESALINATION issue**, one can compare the contributions of the 'local' and 'remote' participants. It seemed that little is known by the "remote" participants and this naturally leads to a search for objective information (9 out of 10 exchanges in the first phase of treatment came from French participants):

	Cumulative	Exploratory	Integrating
Objective	10	3	1
Social			2
Subjective		5	1

Table 4: Seawater desalination, discussions in the first phase, Mars 14 to May 15 (22 entries)

The first French wiki talked about the problem with a reserved attitude. They took the position of distanced commentators and their group did not feel compelled to commit to a position. They did not enter into the topics proposed for the wiki and only one of the four participants gave the only contribution to finding a possible action. They considered the issues on a global scale but did not engage with local contextual interests and alternative approaches. On the other hand, the Australian students positioned themselves as activists in their consideration of the issues. Their wiki was much more focused on social and technical aspects of local controversy. While one of the two participants reported extensively on the views of stakeholders, the other listed possible solutions implemented locally such as the use of "rainwater tanks". This situated approach seems to have led them to tackle more political issues.

3.2 International interaction and growth in understanding of other perspectives

To what extent did our design work engage students in genuine debate? The discussion about the desalination issue of the first phase was very cumulative, then became exploratory in the second phase during Franco-Australian exchanges (period from May the fifteenth to June the seventeenth). Each highlighted aspects of the controversy he or she considered important, and brought them to the debate. For instance: (French student) *" You* *bring a substitute solution which we French students had not thought about "Using rainwater tanks on all houses to supply water". This idea does not seem to me to answer the need for water in Australia. […]. Rainwater tanks are ineffective in this use."*(Answer of an Australian student) *"I too agree that rainwater tanks are not the solution. However, in saying that, they can be a great way to save a lot of water. My family live in country Victoria […]and are completely self sufficient in their water use through installing two large rainwater tanks. […] Therefore, I believe by most houses being able to supply even a small portion of their daily water use from rainwater tanks, it can help alleviate the water shortage we have here."*

The complexity of the controversy is explored further in that second phase, especially in the second column (13 entries out of 27) that identifies the stakes for participants:

	Cumulative	Exploratory	Integrating
Objective	4	5	2
Social		4	1
Subjective	4	4	3

Table 5: Seawater desalination, international exchanges, May 15 to June 17 (27 entries)

The attitude of the international group became proactive and each participant through investigation built their critical thinking. It seems here that international exchanges have contributed to more than the juxtaposition of elements. They have led everyone to be clearer with his or her own position.

The **MEAT CONSUMPTION issue** is also one in which personal context is very apparent. Very quickly in the forum, exchanges moved to declaration of each individual's consumption of meat which placed the problem in a personal context and displayed identity commitments: *"I come from the southwest, a part of France where food is very important. At my grandmother's for dinner …."* "*We Aussies like our barbies"…* Different aspects of the debate were opened up, as different positions were dealt with: "*Looking at it from an individual perspective, I believe that it would be impossible logistically to outright stop meat production. Too much is reliant on its continuation (people's livelihoods, demand within the market, obvious health benefits etc)".*

But the construction of the wiki tended to be organized around a division of labor (no action on the French wiki involved the removal or modification of what others had written), with a propensity to neutralize the discussion.

	Cumulative	Exploratory	Integrating
Objective	14	8	2
Social	2	3	1
Subjective	6	4	1

Table 6: Meat consumption, discussions in the first phase, Mars 12 to May 15 (41 entries)

Note that in the first phase, entries are mainly references to the objective world (first row, 24 of 41) and result in a juxtaposition of individual claims (first column 22 of 41). The attitude of the group is retroactive, the communication mode is the "strategic action" of Habermas and the activity is considered as a presentation. The partners are building a common knowledge accumulation, but the decision for action is vested in the reader.

In contrast, the second phase of exchanges is distributed more evenly between the three lines, and three columns.

	Cumulative	Exploratory	Integrating
Objective	4	2	3
Social	5	7	1
Subjective	3	8	6

Table 7: Meat consumption, international exchanges, May 15 to June 20 (39 entries)

As with the desalination issue, the activity of the group became proactive and generated more "communicative action", referring to the three "worlds" of Habermas. The discussion became more exploratory. The wiki was seen as a rational presentation of views, which may be different.

Conclusion

The interactional socio-scientific reasoning framework proved fruitful for analysing these online community interactions, in particular because it opened up new ways of looking at these exchanges and it helped to understand that reasoning collectively at a high level require arguments across the three worlds in integrative exchanges. We can argue that features of the digital environment both support and constrain students' reasoning on SSIs, with a lack of dispute in forums and wikis, and the problem of distribution of responsibility on the one hand, and with the value of the international forum in creating the requisite disturbance on the positive side. We conclude that cross cultural exchanges add to the richness of student reasoning both through local vs remote perspectives, and different cultural standpoints. Our team is now developing a new research aiming at a better balance between face to face and online position development. We propose a hybrid system in which students will debate in class, in groups, prior to the use of the digital platform to develop the wiki. We will maintain a commitment to an international forum in which the wiki of each group is opened to scrutiny by the other.

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MORAL DEVELOPMENT IN SCHOOL SCIENCE TEACHING: EXPLORING AN INTERFACE OF CONTRIBUTIONS

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Abstract: In the field of Science Education there are many arguments in order to take more attention to the axiological and attitudinal dimensions of the teaching and learning scientific disciplines processes. This demand requires continuous in-depth investigation about this theme because it involves the knowledge of various theoretical fields that have not still attracted the deserved attention. In the light of developmental psychology and discursive ethics, the present study focuses on a relevant component of the attitudinal-axiological dimension: the moral development of students in Science classes. Based on the sociomoral perspectives in Piaget, Kohlberg and Habermas theories, we have attempted to answer the following question: What correlation can we establish between the moral development of students and school science teaching? Following this point of view and the respective problem, we present outcomes of a study containing arguments that explore a valid and viable correlation of secular and rational theoretical and practical aspects and components between school science teaching and moral development, including an analysis of the knowledge about moral, critical and scientific thinking of students learning science. Our study demonstrates the existence of an interface of reciprocal and plausible theoretical and practical contributions between moral development and school science teaching, which has so far received little attention in the Science Education research.

Keywords: science teaching; moral thinking; socio-scientific issues; Kohlberg; Piaget.

DEVELOPMENT MORAL: AN ATTITUDINAL-AXIOLOGICAL DIMENSION IN SCIENCE EDUCATION

The epistemic factors have received increased attention in Science Education research. However, non-epistemic factors (moral, affection, political etc.) have so far been little explored. We understand that more consideration should be given to these non-epistemic factors since they also integrate the lines of reasoning and arguments in the decision making process for addressing technical and scientific issues (Acevedo, 2006). Solbes (2009) presents another line of discussion, though with similar concerns. The author affirms that the difficulties encountered by students in learning Science are not restricted to conceptual deficiencies because the process of conceptual learning is aligned to several other aspects like reasoning strategies, affective relationships, classroom atmosphere and motivations. These aspects can be either, favourable or unfavourable to the teaching and learning of science; in this case, the procedural and axiological dimensions are also necessary in conceptual learning.

In the Science Education research literature we have found other arguments that support the need for attention to the axiological and attitudinal dimensions in the science teaching (Zeidler, 2003; Lemke, 2006; Sadler et al., 2006; Reis, 2007). Nevertheless, we found few studies about this subject, which should deserve more attention due to the relevance and complexity of the theme, which involves other knowledge fields such as philosophy and psychology.

In the light of developmental psychology and discursive ethics, the present study focuses on a relevant component of the attitudinal-axiological dimension: the moral development of students in science classes. Based on the sociomoral perspectives in Piaget, Kohlberg and Habermas theories, we have attempted to answer the following question: What correlation can be established between the moral development of students and school science teaching? Our study was focused on moral development because the theoretical foundations of this process may help us understand students' moral reasoning and creative thinking construction. According to Simmons and Zeidler (2003), there is an interaction between these two constructions that should be better explored in science education. Our study attempts to help exploring these possible contributions.

Following this outlook, and based on the above mentioned problem, the present theoretical study explores correlated aspects (of principles, contents, procedures, etc.) between moral development and school science teaching. Within the scope of this synopsis, we briefly present: i) a set of ideas and principles of education, science education and sociomoral perspectives according to Piaget, Kohlberg and Habermas; ii) a delineation of arguments, exercises and analyses that contemplates a juxtaposition of aspects and components under the sociomoral perspectives and the axiological needs about the science teaching, configuring a delineation of potential correlations between school science teaching and students' moral development.

SCHOOL SCIENCE TEACHING AND SOCIOMORAL PERSPECTIVES: THEORICAL APPROACHES

Some of the identified principles and ideas in Education, Science Education and sociomoral perspectives that we followed are: i) Education implies in moral formation; ii) school education plays a relevant role in the "search for the truth"; iii) The science curriculum should include ethical and moral issues, implying in theoretical and practical needs to support these discussions; iv) Science and science teaching present ethical and moral aspects at different plans and logical levels; v) Science versus religion, idea and search for the truth, common sense, nature of science, scientific practice, controversial socio-scientific topics and discourses / languages on science are components presented in science classes that have the potential to generate in students critical thinking and intellectual and moral independence; vi) According to Piaget, the morality is not innate, but also acquired by learning; vii) Piaget (1992) reports two stages of moral: *heteronomy* – obedience motivated by either, external or self-centred control (e.g. fear of punishment) - and *autonomy* – obedience motivated by internal consciousness; viii) Imposition, coercion and unilateralism are elements that do not lead to autonomy, because they reinforce heteronomy; on the other hand, cooperation, dialogue and mutual agreement are key elements for developing moral autonomy (Piaget, 1992); ix) Kohlberg (1992) indicates three levels of moral development: *Pre-Conventional* – guided by obedience, punishment, selfish-naïve of submission to a higher force; *Conventional* – centred on conformity to the conventional order and on meeting other people's expectations; *Post-Conventional* – characterized by the distinction of valid values and principles regardless of the authority; x) The ethical discourse is a form of communication aimed to justify the claims of validity of opinions and interaction norms. By means of the language, a consensus completely free from external and internal coercion is sought. We may assume that something is good or real by using force or imposition (heteronomy) or by establishing a dialogue (autonomy) where other people's arguments may change someone's opinion. In the first case, there is a supposed authoritative power (heteronomy); in the second case, a validity claim. When the supposed authoritative power prevails, the argument of force is applied (unfavourable to moral development). When people are open to validity claims, they are guided by the force of arguments – which favours moral development (Habermas, 2008); xi) Piaget, Kohlberg and Habermas theories are based on rationalism, cognitivism, constructivism and moral principles of justice, cooperation, equity and truth.

DELINEATING CORRELATIONS BETWEEN MORAL DEVELOPMENT AND SCHOOL SCIENCE TEACHING

Various theoretical and practical aspects and components extracted from education, science education and sociomoral perspectives can help us to organize two "moral atmospheres" – concepts adapted from Kohlberg (Table 1). Each one of them combines elements that may, by means of correlation, reinforce moral heteronomy and cause damage to the teaching of Science, or guide the search for moral autonomy and to favour science learning.

Table 1 Two "moral atmospheres"

Atmosphere of moral autonomy and for favouring science learning (some examples)	Atmosphere of moral heteronomy and damage to science learning (some examples)
• Obedience motivated by internal control.	• Obedience motivated by external control.
• Does not impose an a priori truth to the child; the child is not compelled to accept such truth.	• Imposes an a priori truth to the child, who is compelled to accept it.
• Centred in post-conventional level.	• Centred in pre-conventional level.
• Use of discursive arguments with validity claims.	• Use of discursive arguments, with a supposed authoritative power.
• Prevalence of Habermas' theory of communicative action.	• Prevalence of instrumental action.
• An idea of provisional truth and science as a process.	• An idea of absolute truth and science as a finished product.
• Science is not considered a monolithic authority.	• Science considered as a monolithic authority.
• Critical and non-relativist understanding of the different types of knowledge.	• Uncritical and relativist understanding of the different types of knowledge.
• Non-scientific knowledge brought by students that are not previously rejected, nor contemptuously ignored.	• Non-scientific knowledge brought by students previously rejected or contemptuously ignored.
• Demonstration of real interest in the subject while "talking about science".	• No real interest demonstrated in "talking about science".
• Mobilization for students' critical stance towards different types of "evidence" (favouring a critical stance of students towards their initial beliefs).	• "Lack of mobilization regarding the "blind faith" of students on "their evidence" (persistence of an uncritical stance).
•Understanding that surpasses an internalist view of science.	• Understanding that does not go beyond the internalist view of science.
• Ideas, principles, procedures and contents that favour an accessible science.	• Ideas, principles, procedures and contents that favour an inaccessible science.
• Scientific knowledge is not used as an instrument of oppression, coercion or constraint.	• Use of scientific knowledge as an instrument of oppression, coercion or constraint.

We used these approaches in various exercises in real and hypothetic situations to support our arguments for delineating correlate contributions between school science teaching and moral development. Table 2 includes some of these analyzed exercises.

Table 2 Analyzed exercise

Enunciation: *Researchers of the University of California found in the United States Department of Defense a document that classifies homosexuality as a "mental disorder"* (Science Teacher - Partially simulated situation).	
Hypotheses	**Moral atmosphere (implications for moral evolution and learning of Science)**
Science teacher in a reduced and merely informative discourse without proposing a debate or critical stance towards the event.	Reinforcement of moral heteronomy and damage to the teaching of Science: Idea of absolute truth and science as a finished product; strategies that stimulate students' moral reasoning of the students are not used; controversial themes to be discussed in classroom are not included, or there is poor use of such themes, which does not mobilize critical thinking and the development of autonomy; truth is not a value to be sought; understanding does not go beyond the internalist view of science, etc.
Use of discourse as a strategy of debate by the Science teacher.	Search for moral autonomy and in favour of the learning of Science: Idea of a provisional truth and science as a process; use of strategies that benefit heterogeneity and diversity in science classes, aiming at promoting students' moral reasoning development; use of controversies, by means of dilemmas and their respective moral reasoning; truth as the value to be sought; understanding that goes beyond the internalist view of science, etc.

SOME OUTCOMES

This study shows that we were able to confirm the existence of an interface of valid, plausible and viable correlated contributions between the aspects and components of the secular and rational theoretical and practical foundations of moral development and school science teaching – an interfacial correlation that needs further investigation. The possibilities of contribution identified represent a two-way process, that is, as science teaching potentiates the moral development in students, it also enhances science teaching and learning and vice-versa (as science teaching and learning is potentiated, through the several presuppositions underlying the axiological needs, students' moral development and critical autonomy is also potentiated). In short, there is a very important relationship between the two processes, as showed below (Figure 1).

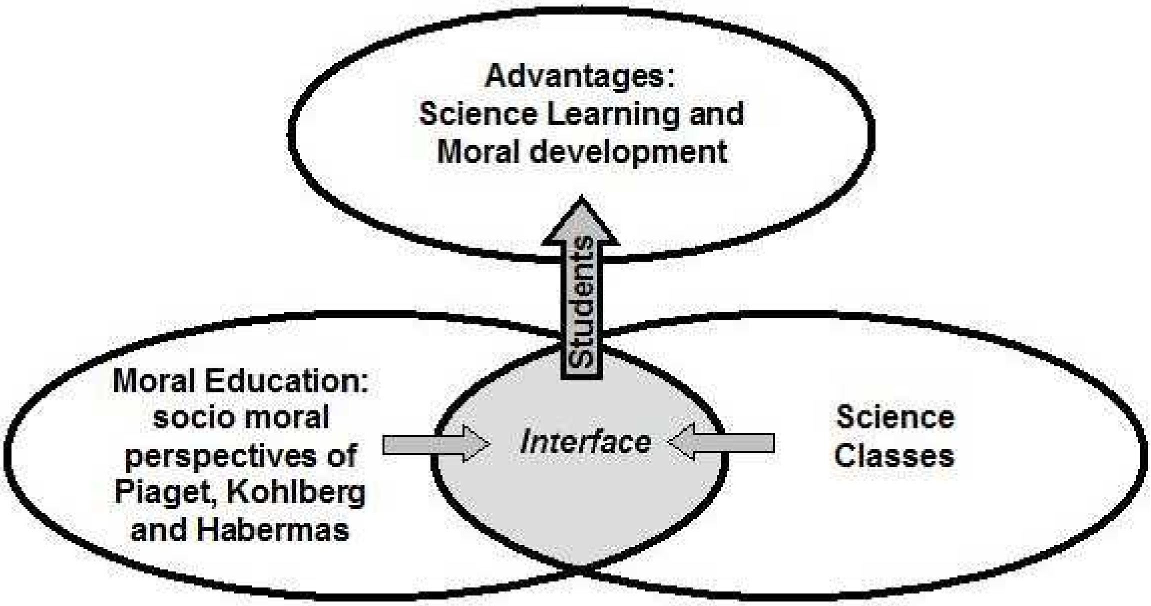

Fig. 1 Interface of contributions

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CRITICAL READIND ACTIVITIES TO DEVELOP CRITICAL THINKING IN SCIENCE CLASSES

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Abstract: The aim of this research is to identify the difficulties experienced by secondary school students (aged 15 to 16) with the critical reading of newspaper articles with scientific content. Two newspaper critical reading activities in relation to the study of various scientific contents were designed and carried out in two schools (61 students in total), one with a student population from a medium to high social and economic bracket (school 2) and the other with students from a medium to low social and economic bracket (school 1), and both with different teaching methods. In school 1, the students usually worked in cooperative groups and discussion and self-regulation by students were encouraged. The methodology could be considered to be "student-centred-oriented" according to the classification devised by Kember (1997). In school 2 particular emphasis was placed on reading comprehension and on writing abilities across all areas but, on the other hand, the students never worked in cooperative groups. The teaching was based on the transfer of information by the teacher and the methodology could be considered to "teacher-centred-oriented". The two schools were characterised by the importance placed on experimental work. In order to analyse the difficulties "Elements of Science Critical Reading" were identified on the basis of the "Elements of Reasoning" of Paul & Elder (2006) and the categories proposed by Bartz (2002) in his C.R.I.T.I.C. questionnaire and a scale was drawn up.

Keywords: Critical thinking, literacy, high schools, abilities and critical reading.

INTRODUCTION

Background and rationale

Reading is a fundamental process in science learning since it is not only one of the most often used resources during the school years but can also become a basic tool for ongoing learning throughout life. The media and particularly the written press provide the main sources of scientific information for most adults (Jarman & McClune, 2002). In these media, opinions and actions are often based on scientific knowledge which the reader needs to know how to analyse critically.

Reading means understanding, interpreting, analysing and criticising texts. This is the basic meaning of literacy (Norris & Phillips, 2003). Critical reading and, therefore critical thinking, depend on the context and culture in which they are situated (Yore, Craig & Maguire, 1998). In this research we have focused on assessing critical thinking abilities based on the proposal by Paul and Elder (2005) and Bartz (2002) in the form of the C.R.I.T.I.C acronym. Based on these two approaches, we identified certain "Elements of science critical reading" that we considered useful to guide the critical reading of newspaper articles with scientific content and also to analyse students' difficulties (see Table 1).

Objectives of the research

The specific objectives of the research are as follows:

1) To analyse students' difficulties in applying the "Elements of science critical Reading" defined in the reading of press articles.
2) Identify in relation to which "Elements of science critical Reading" differences are detected in the two samples analysed (school 1 and school 2).
3) Identify how the content of the readings and the types of questions raised in the activities affect the students' answers.

METHODOLOGY

Project description

The first phase of the research consisted of selecting two newspaper texts with scientific content. The subject of the first article was the difficulty involved in removing graffiti on glass. According to the author of the new report, graffiti on glass is so difficult to remove because graffiti writers mix acid with the paints they use. This article was chosen so that the students could apply their knowledge of chemical change. Since the information in the text was not completely correct, because acids (apart from hydrofluoric acid) do not react with glass, the students were able to question the scientific basis of the news story. The second article contained opinions for and against whether the swimsuits used by swimmers had helped improve the latest Olympic records. In this case the article was chosen so that the students could apply their knowledge of cynematics and dynamics to the analysis of an actual event.To encourage critical reading of the articles and reflection, two critical reading activities were proposed (activity 1_ Grafittis and activity 2_ Swimsuits) which included questions relating to those shown in Table 1. There were other methodological strategies related to cooperational learning and group discussion (Márquez & Prat, 2005; Oliveras, Márquez & Sanmartí, 2011).

"Elements of Science Critical Reading"	Examples of question types posed in classroom activities
1. Identify the main ideas of the text	-What problem does the text present? What is the main idea?
2. Identify the writer's purpose	-Who wrote this document?-Why must he or she have written it?
3. Identify the writer's assumptions and viewpoints	- What assumptions does the writer make in the text? Are they justifiable?
4. Formulate a scientific question which the writer answers in the article or design a scientific experiment to verify the information in the text	-Could an experiment or test be carried out to verify the credibility of the main assumption? What question would a scientist ask to investigate this problem?
5. Identify data and evidence given in the text	-Are there any arguments or scientific evidence in the text that support the initial assumption? Write them down.
6. Draw conclusions based on the evidence	-Are the conclusions in line with the current scientific knowledge you have?

Table 1. "Elements of science critical reading

Research population

The research was conducted in two secondary schools in Catalonia (Spain). School 1 is situated in Barcelona and its students come from a low social and economic bracket, with 30% of them being immigrants. School 2 is in a town, near Barcelona with a population of 4,000 and its students are from a medium to high social and cultural bracket, with 9% being immigrants. A total of 61 students took part (15 to 16 years of age), 30 in school 1 and 31 in school 2.

Data analysis

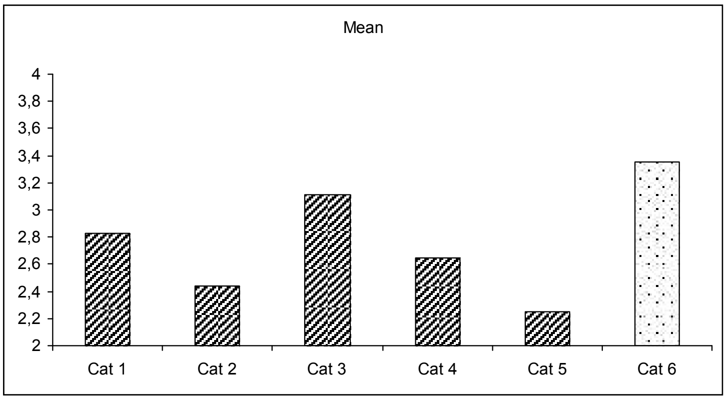
Based on the "Elements of critical reading" we defined six categories used to analyse the data collected in this study. Depending on the students' answers, a scale of 1 to 5 was devised. The scale and the classification of the students' answers were validated by two experienced teachers.
The average scores in each category between the two schools and the two activities were compared, together with the interaction between them, using a two-way analysis of variance (ANOVA). All statistical tests were assessed as significant when the p values obtained were less than 0.05.

Codes	Categories
C1	Identification of the main ideas of the text
C2	Identification of the writer's purpose
C3	Identification of the writer's assumptions and viewpoints
C4	Formulation of a scientific question which the writer answers (article 1) or Design of a scientific experiment to verify the information in the text (article 2)
C5	Identification of data and evidence given in the text
C6	Arguing conclusions based on evidence

Table 2: "Codes and Categories"

RESULTS AND DISCUSSION

To achieve objective 1 of the research we focused on the means in each category. The results (see Figure 1) show that category 2 (identify the writer's purpose) and category 5 (identify data and evidence given in the text) were those that students found the most difficult overall.



"Fig1. Average scores in each category"

In relation to category 2 the results can be explained by the fact that most of the students were convinced that the purpose of the text was to inform and that this information is always neutral and unbiased. Very few students detected that there could be a particular intention in their written work.

With respect to category 5, the difficulties detected related to the assumption by the students that a journalist is an informed and qualified person. If, in addition, the text contained a word that they considered to be scientific (acid, floatability, concentration, etc.), they considered this to be a sufficient indicator to support the scientific basis of the news story and, therefore, they saw it as proof of what the writer said.

To achieve objective 2 of the research we compared the results of the two schools according to the various categories. The results in Table 3 show that there was a significant difference between them with respect to categories 1, 4 and 6.

	School 1	**School 2**	**p**
C1	2.23±1.0	3.43±1.2	<0.01
C2	2.20±1.0	2.69±1.2	0.184
C3	2.78±1.3	3.41±1.3	0.069
C4	2.31±1.0	3.00±1.4	<0.05
C5	2.30±1.2	2.21±1.0	0.128
C6	4.26±1.1	2.44±.5	<0.001

"Table 3. Means plus standard deviation (mean± SD) for each school (N=61)"

Table 3 shows that the results in categories 1 and 4 were better in school 2 in the two activities whereas the results in category 6 were better in school 1 in the two activities. To explain the results we took into account the differences in the teaching methods used at the two schools.

In relation to objective 3 of the research the results of the activities carried out were compared according to the various categories (Table 4).

	Activity 1 (Graffiti)	Activity 2 (Speedo)	p
Cat 1	2.88±1.4	2.81±1.2	0.821
Cat 2	2.60±1.2	2.31±1.1	0.251
Cat 3	2.91±1.5	3.24±1.2	0.323
Cat 4	2.10±0.6	3.11±1.4	<0.05
Cat 5	1.30±0.7	3.04±0.7	<0.001
Cat 6	3.50±1.6	3.25±1.7	0.804

Table 4.Means plus standard deviation (mean± SD) for each activity (N=61)"

The results show that there are significant differences in categories 4 and 5, but not in the rest. As for category 4, activity 1 (graffiti) required the students to formulate a problem that could be scientifically investigated, without the text giving any clues. In contrast, in activity 2 (swimsuits) the problem was presented and the students were asked to think of a scientific experiment to prove whether or not the swimsuits contributed to improving swimmers' speed. As could be expected, the results showed that the students found it more difficult to think of problems that could be scientifically investigated than scientific experiments that could be performed to answer a question.

Category 5 was also very different in the two activities. It was shown that the information provided in the text had an influence on recognising the evidence. If the texts contained information with a scientific basis, the students who understood the scientific model then recognised it. On the other hand, students invented evidence or made unfounded assumptions since, initially, they were completely confident that the writer's statements were true.

CONCLUSIONS AND IMPLICATIONS

The students' answers show that it is not easy to apply critical thinking to the analysis of texts. We identified that there are aspects of critical thinking where students have greater difficulties: identifying the writer's purpose (C2) and looking for evidence in a text (C5) (Figure 1). Significant differences were detected between the two schools (Table 3). The students at school 2 showed greater reading comprehension abilities and written expression (C1) but, on the other hand, they had more problems with the critical analysis of the texts (C6). We can assume that the social and cultural level of these school's students helps them achieve better reading comprehension and writing skills. As for the problems with critical analysis of the information, we believe that these could be due to the different teaching methods used in science classes in the two schools (Kember, 1997). In school 1, the students work on science in a more reflective way, interaction between students and between the students and teachers is encouraged.

In this study we put forward a proposal for working critically with newspaper articles but we think that without a belief in the importance of class discussion (Paul, 1992) on the interpretation of facts with a scientific basis it is difficult for students to develop critical thinking. Authors such as Osborne (2010) and Hayes & Devitt (2008) take the view that collaborative discourse between students represents the ideal means to help students improve the quality of their thinking, always taking into account that discussions need to be regulated and guided by the teacher.

We also detected significant differences in some categories depending on the activities involved (Table 4). Specifically in category 4 and in category 5. In relation to category 4, the students had more difficulties formulating a scientific question relating to a subject than in designing a scientific experiment to verify specific information in the text. As for category 5, if the text does not contain scientific arguments, data or evidence to support the information, the students make unfounded assumptions and consider them as such, since they are convinced that information always has a basis.
We can conclude that the critical reading activities analysed helped to connect different concepts studied in science classes and apply them to the analysis of a real-life problem. After carrying out the activities, the students asked to do more of them which means we can say that they encouraged an interest in reading current texts and analysing them critically, besides applying the scientific knowledge they had learnt. This suggests that students find this type of activity motivating (Nolen, 2003).
Lastly, it is important to state that the objectives associated with critical reading cannot be achieved in a single activity and, therefore, they must be included regularly throughout the students' school career.

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TALKING SCIENCE: THE POPULAR ASTRONOMY OF CAMILLE FLAMMARION [1]

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Abstract: In scientific practice, there is no image by image. The image is still regarded as a process, the result of a theory or reasoning or a model representation. This article will introduce the discussion on the functioning of images in a popularization science work. We analyze the fifth edition the “Astronomy Popular” of Camille Flammarion. In this study we have taken the discourse functioning concepts proposed by Michel Foucault to analyze one semiotic system. In conclusion the study indicates a functioning of illustration and a demonstration of the evidence "do science" in this work.

Keywords: Camille Flammarion, the popularization of science, the discourse functioning, popular astronomy.

INTRODUCTION

Image in science is an association among a technical process, a referent, a phenomenon or an object that one wants to observe or represent, as well as a scientific model. Without these associations, an image in science is just a visual element, a characteristic which marks the memory. It may be a summary of an equation, a mathematical or physical concept or even the creation of lines and colors of a mathematical model. According to Sicard (1997), these images have two iconic paradigms: the first, similar to photographic, a tool captures a fraction of real object, while the second captures a diagram of operation, punctuates what must be seen. The images in scientific research apparently belong to the second paradigm, nonetheless the science popularization should be working more with the first one. It is this assumption which directs our work to investigate the functioning of the images included in a science popularization text.

The images in sciences to Latour (1997) are often "technical images", the result of an "regard orchestrated" by artifacts or theories. The image capture, however, is not enough for science. Robert Hooke and Antonie van Leeuwenhoek, through the microscope which was built in the seventeenth century, observed the plant cells. Only a century later, the cell theory could give a meaning to this observation.

Astronomy has a pioneering role in the development of images in sciences. The introduction of the telescope, according to Bennett (2007), has transformed the instruments of astronomical observation in the seventeenth-century. Until 1609, before the construction of the astronomical telescope of Galilee, astronomers with only the power of their eyes and looking at a small fraction of the electromagnetic spectrum started the adventure of sciences with the image in meticulous drawings which were the instruments of their arguments.

The images produced by science have become more and more complex in the extent that technology has the interaction with possible differentiated levels of energy in production. The new instruments: an electron microscope, a positron camera or a system of satellite-tracking, on the other hand, have lost the dialog with the human dimension. In this context, I will discuss, in seeking to query its pragmatic functioning within science popularization discourse, all contained in the 1955 Nicolas Camille Flammarion fifth edition of "Popular Astronomy”.

THE IMAGE IN DIALOG WITH A TEXT

When we talk about images inserted in sciences text, two natures emerge. The first nature of the image is the reflection on a mirrored surface, and the second nature of the illustration is the representation pictorial, which indicates what seems to be seen. I will consider Michel Foucault’s definition (2000) of discursive procedures group which coordinates the discourse order. Such works differentiate the penetration of subjects in the discourse products. The image is an important element in all languages: natural, mathematics, iconic, graphics among other things and, it may be considered a component of a communicational act where social actors build and share a universe of meaning.

To consume the communication act, the interlocutors are legitimate as communicating subjects who share intentions, purposes, intersubjectivites and ways of expression adjusted to the communicative situation (Nascimento, 2007).

In the study that we propose in this article, we analyze a general public book, which we can characterize as a science popularization work. The studies on science popularization texts, developed by Daniel Jacobi (1998), indicate a dynamic of writing around the concepts and the scientific terms which are employed for the circulation of scientific knowledge outside from their production and validation sphere.

THE POPULAR ASTRONOMY OF CAMILLE FLAMMARION

For Carle and Guédon (1988), science popularization, non-formal or informal education composed by a nomenclature, is still subject of controversy, but these authors suppose that we are talking about the promotion of public access to knowledge and to scientific and technological information by means of mechanisms of differentiated schooling. The astronomer Nicolas Camille Flammarion (1842-1924) has devoted his life to the disclosure of astronomical research. Its main publication, "Popular Astronomy", was published in 1879. His work includes books, directories and journal articles and, in 1882, he founded the Popular Astronomy magazine, a monthly bulletin which were broadly disseminated.

For Jeanneret (1994), Flammarion participates in a "extension program" committed "to say the reality" by proposing moving away from a theoretical discourse which characterizes the scientific language. Popular Astronomy presents very rich and some colored pages and it is a continuous text, cut by chapters with attractive titles, for example, the Earth in the sky. Eventually, the title is accompanied by a brief indication of the covered subjects: how Earth turns on itself and around the Sun... Each illustration has a title, which sometimes, is reported in the text. Before it, there is a text to read in its entirety, similar to other texts about the disclosure of time (JEANNERET, 1994: 256).

In all the six books, as well as on the astronomy´s instruments annex directed to amateurs astronomers, we find 819 images numbered, two celestial charts, tables with astronomical data and an index. Most of these images (607 out of 819) are photographs with illustrative function surrounded by Jacobi´s framework. There are also celestial and land charts (28), systems of graphs (155 tables, graphs and diagrams) and schemes (29). The presentation of each book is almost always preceded by a colorful image, being all the other photographs in black and white. The intention of the popularization without trivializing science is reached from restatements of scientific discourse considering the first discourse. The science popularization discourse, with the restatements which are characteristics, is well marked, for example, by the complete explanation of elements which make up the project.

> Camille Flammarion aimait dire qu'il faut vulgariser la science sans la rendre vulgaire. Telle est la formule qu'il a appliquée dans cette Astronomie Populaire, dont le succès immense a contribué à répandre les connaissances astronomiques et a suscité de nombreuses vocation d'astronomes.Mais cet ouvrage irremplaçable exigeait aujourd'hui une refonte complète: sans en altérer le plan, il convenait d'y introduire les étonnates découvertes de la science contemporaine, et notamment un tableau de l'univers sidéral d'une telle ampleur que l'imagination bardie de Flammarion lui-même n'arait jamais osé le concevoir. Heureusement, l'éducation scientifique du public actuel l'a préparé à recevoir l'enseignement direct des faits et à goûter la poésie des spectacles grandioses qu'un abondante illustration photographique met ici sous ses yeux. (1955:p.3 griffin our)

In this book, the discourse, in general, is restated by the explanation in different languages, for example, the photography below 351 (p.249) which illustrates the nuclear reactions represents a descriptive form (1 Carbone^{12} + Proton = Azote^{13} + Energy) and an explanatory text.

IMPLICATIONS FOR THE SCIENCE POPULARIZATION

The images can be thought, in the case of Flammarion's science popularization work, in a dynamic among instruments, real object and its representation. This "real object" is an ideal shared by the French popular education program, by the time it approached sciences speech and scientific education, movement which still been observed in the 20th century, in the constitution of scientific culture associations (NASCIMENTO, 1999). The use of photographic images can be interpreted as this "explanation of real".

The interest on the image in this work can be attributed to its evidence value. The development of photography, in the 19th century beyond being an element of proof, in the science popularization discourse brings the traces of the object observed involved by delight and emotion. There is in this edition, also an attention to show images of scientists in pictures, paintings, engravings, and in scenes of using instruments. The illustration functioning favors the sensational aerial photo images, as well as inaccessible spaces: polar landscapes, Earth or global images, images of the limits of the universe, among others. These works still can be observed today, in the election science popularization images in this science area. A relationship ever investigates how these images can be found in other sciences writing traditions, and in the science teaching. In this study, however, we introduce this theme for the discussion toward opening other possibilities for future analyzes.

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DEVELOPING A MODULE ON STEM CELLS: STUDENT-TEACHERS' MEDIA INQUIRY

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Abstract: This paper studies the media inquiry of a group of Greek student-teachers which took place in the context of a science education course. Its goal was to identify media information appropriate for the introduction of knowledge concerning stem cells into school classrooms. Materials collected by student-teachers and their teaching plans are the data of the study. Findings show that student-teachers accessed a substantial number of media, mainly electronic sources. The public domain of science as portrayed in student-teachers' collected material seems to affect the kind of thinking they develop and also their teaching plans. Private stem cell banks' sites seem to be a major source of information for student-teachers, though few sources can be considered reliable. Their awareness of socio-scientific issues of this nature needs further development and evidence suggests that there is a need for more specific guidance to be included in the teacher education course activities.

Keywords: Socioscientific issue; Stem cells' learning; Student-teachers' inquiry; Biotechnology education; Media literacy

INTRODUCTION

Although textbooks play a dominant role at nearly all levels of the educational system, students are also exposed to several other text-based sources of information in most subjects. There has been an immense increase in the availability of digital information sources over the last decade, with many students being exposed to easily accessible information related to study tasks. On the other hand, such an information overflow represents a challenge regarding the way in which information is processed and comprehended, and demands new approaches in classroom science teaching as well as a different role for the teachers. Proficiency in the meaningful reading of multiple texts and acquiring and integrating knowledge from a series of written documents is not supported by current school and university teaching practice.

Members of a modern society are continually bombarded with information from innumerable, often conflicting, information sources, requiring individuals to cope with challenging reading tasks on a daily basis. In dealing with such complex tasks, people need to make choices about which information to attend to and trust (Strømsø et al, 2008). A large body of this information refers to new scientific issues, such as nanotechnology, climate change and biotechnology, all related to science teaching and crucial for citizens' everyday life. The importance of taking into account such aspects in science teacher education courses is the focus of this study.

RATIONALE

Transforming the pedagogy of school science is a major challenge as two features prevail: the "collective culturally embedded notion of what it means to teach science" and the "assessment system which overwhelmingly values the reproduction of factual information as the best measure of a knowledge and understanding of science" (Osborne, 2007). As (it) has been described by National Research Council (1996), teachers' professional development comprises opportunities for intellectual professional growth, introduction to scientific literature, media, and technological resources that expand their science knowledge and experiences to access further knowledge. It has also been argued that science courses need to offer prospective and practicing teachers the opportunity to learn about science through inquiry. This perspective is based on a hypothesis. The form of professional development, including research experiences for teachers, will probably allow teachers to experience scientific inquiry in the hopes that these experiences will then translate to inquiry in the classroom. Research evidence has shown that teachers who entered the program with a more sophisticated, theory-based understanding of teaching and learning were better equipped to understand inquiry as a model and to use classroom-based inquiry throughout their teaching on completion of the program (Blanchard, Southerland, Granger, 2009).

Another goal of science teachers' programs is related to perspectives that view and support teachers of science as the representatives of the science community in their classrooms. In attaining these goals, student-teachers' scientific and media literacy are of great importance. Media is a key element in the mediation of the "relations of definition" between science, the public and the political spheres (Beck, 1992). As new links are established between citizens, scientists, politicians and media professionals, the embeddedness of science and politics has become increasingly public making science more exposed to criticism, contestation and deconstruction (Carvahlo, 2007).

Advances in biotechnology comprise social components as well as scientific components (Halverson et al, 2009) that individuals may consider while developing their opinion about the usefulness of such advances. For example, stem cell research is connected to social acceptability and also to the great economic impact of future stem cell-based therapies (Pompe et al, 2005). So, when teachers today deal in classrooms with concepts such as cells, genetic material and health therapies, they are expected to enhance their students' literacy and critical thinking on such kinds of issues that they may face during their everyday life. Student-teachers' awareness of what in fact scientific advances are, and also of the ways in which such advances are portrayed in the public domain and the media, is considered to be an important goal in their education. One of the three major roles of communication of scientific information in our society is that of popularizing information generated by the scientific community, while Journalistic Reported Versions are considered the representative genre of this type of communication, and a matter worthy of study (Yarden, 2009). Jiménez-Aleixandre & Federico-Agraso (2009) have studied how the argumentative structure of a scientific paper, Hwang et al.'s (2004) paper about human somatic cell nuclear transfer, is presented into four Journalistic Reported Versions (JRV) of it. It has been found out that the argumentative structure of the scientific paper is translated into the JRV giving prominence to the therapy claim. The apparently ostensible main claim of Hwang et al.'s paper about nuclear transfer constitutes a justification for the second claim about its therapeutic applications, for which no evidence is offered. This fact also had an impact on university students' perceptions of the summary of one of the JRV. Most of them identified both claims, nuclear transfer and therapy, citing the evidence and justifications mentioned in the JRV, which were mostly oriented to therapy.

The interest of the present study is on how a module can initiate student–teachers' thinking and actions to handle media science information, to get familiar with current knowledge and debates and to produce teaching material about a new scientifically contemporary topic, the stem cells. More specifically the following research questions are explored here: How **is** knowledge on stem cells represented in the Greek public domain as appears in student-teachers' choices of media material in order to be informed about stem cells? What are the characteristics of the selected media materials?

METHODOLOGY

The research described here refers to a university primary science education course and is addressed to prospective primary teachers. It consists of a number of modules on scientific and media literacy, argumentation and authenticity in science communication, while aspects like the nature of science and the public understanding of science are also included. The general philosophy of the present teacher education course, the design and implementation of the modules, follow a "design research" approach, that makes use of existing traditional research findings to develop some type of 'product', in the case of teacher education, programs for professional development" (Wood & Berry, 2003, p. 195). During one of the modules on media literacy, student-teachers obtain experiences while searching for media articles appropriate to be used in primary science classrooms. Examples of Journalistic Reported Versions of scientific advancements and socio-scientific issues, as well as their use with primary school students have been presented and discussed. One of the topics that was initiated and proposed as the field of inquiry concerned the stem cells. During this inquiry, students searched and selected media material in order to get informed about the topic of stem cells. The further goal was to develop awareness on the stem cell issues in order to build a teaching unit about stem cells for primary students of 6th grade. During their semester exams they had to answer a number of questions on their inquiry and teaching designs. Final products (materials and written replies) of 170 student-teachers for the exam preparation, the outcome of an independent personal media research, are the data of this study. The inductive qualitative content analysis (Mayring, 2000) has been adopted for the analysis of student-teachers' written materials and products. 445 media documents have been analyzed.

RESULTS

The analysis of media materials identified by student-teachers (documents in their portfolio) has led to the construction of a system of dimensions and categories of their characteristics, presented in the systemic network of figure 1. One dimension refers to the *number* of different materials which have been found by the student-teachers. Another refers to the *type of source* from which the information has been tapped. That means if the source is recognized as a newspaper, a magazine or a journal, stem cell banks' information, organizations/associations, wiki-sites or web magazines/sites. They have also been analyzed in terms of the genre of text that the material includes: articles, scientific articles, interviews, descriptive texts, personal experiences and advertisements. The third dimension concerns the *content* of student-teachers' selected documents. Two aspects are examined: what is involved in each document, and its purpose. More specifically, we examined whether the materials involve definitions of stem cells, their types, references to umbilical cord cells, properties, applications of stem cells in medical cases, research issues, controversies concerning moral or political issues, historical information and finally information about stem cell banks or their advertisements.

We also examined whether the main purpose of the document can be considered as offering conceptual information about stem cells, examples of research experiments, as being for medical purposes, promoting private stem cells' banks or posing the ethics of stem cells' use. The last dimension refers to the persons who are involved in the materials either as *authors* or as *interviewees*. These persons, when their identity is stated, can be doctors or researchers, journalists, stem cells banks' representatives, or individual persons who expose their experiences in blogs.

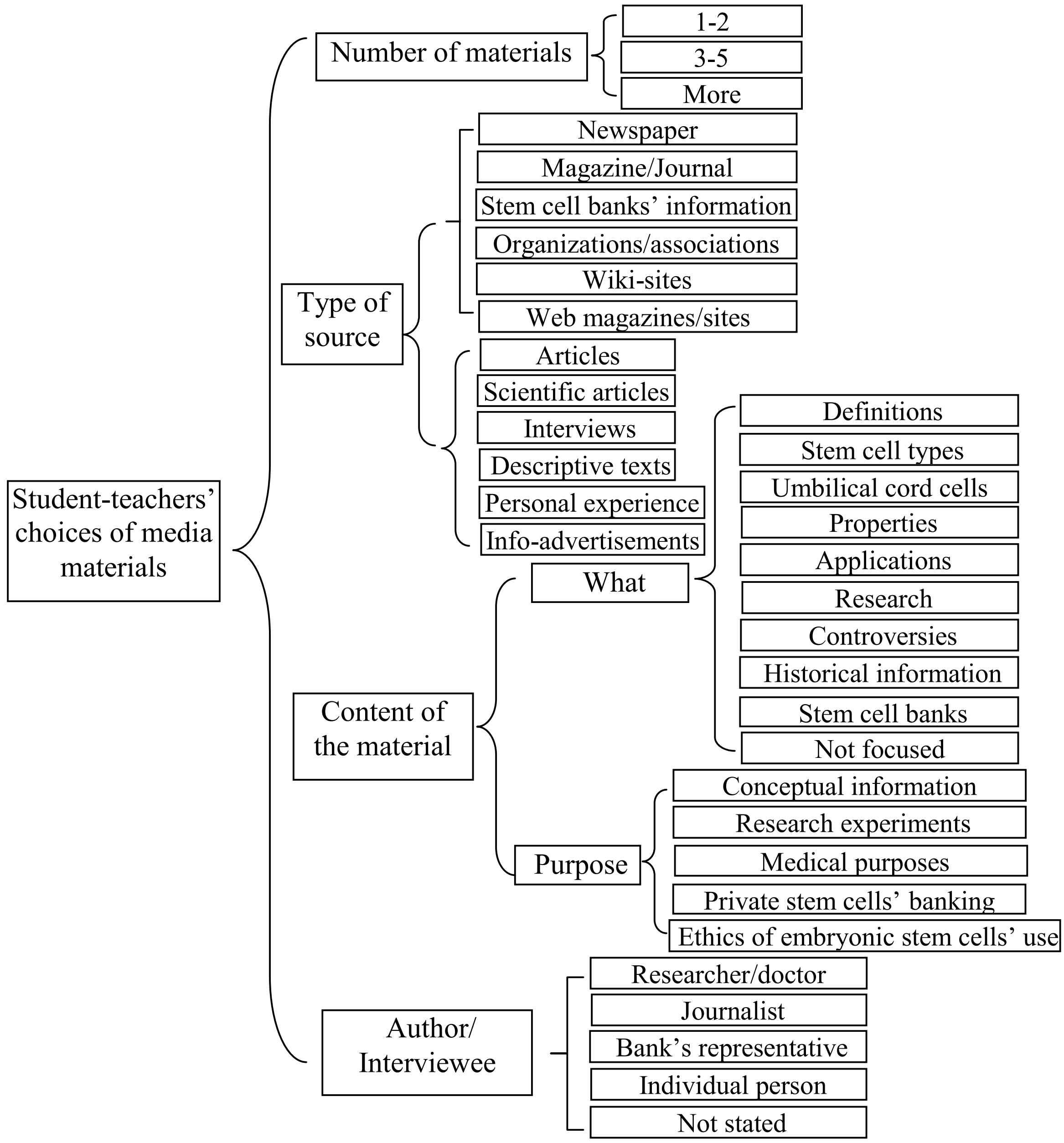

Fig.1 Systemic network of categories: characteristics of selected media material

The findings indicate that **over** one third of student-teachers' documents come from web magazines/sites (Table I), one fourth from newspapers and 14,5% is stem cells banks' information, e.g. electronic leaflets provided by private Greek stem cells banks. This last category is probably due to the fact that 20% of the world private stem cell banks exist in Greece. 11% of the documents have been selected from information, mostly electronic, of Organizations/associations, 9% from wiki-sites and only 7% from Magazines/Journals. In terms of genre, 38% are descriptive texts, 29% articles, 20% info-advertisements, 11% interviews, 9% descriptions of personal experiences/opinions, while only 3,5% are scientific articles. Very few **of** the sources and the identified texts can be considered scientifically valid.

Table II presents frequencies of categories in terms of the content of the selected materials and in terms of the author of the documents. So, the content of the identified documents refers mainly to uses and applications of stem cells (45,5%), followed by stem cell banks' information (43,5%), references to umbilical cord cells (38%), and to controversies on health issues or private versus public safekeeping (33%). 29% of the selected documents **also** contain definitions of stem cells, 24% describe stem cell types and 18% stem cells' properties.

TABLE I: Frequencies of the categories of characteristics			
Aspect		**Category**	**Percentage/ Frequency (%)**
Number of documents		1-2	55
		3-5	36
		More	29
Type of document	Source	Newspaper	24
		Magazine-Journal	7
		Stem cell banks' information	14,5
		Organizations/associations	11
		Wiki-sites	9
		Web magazines/sites	34,5
	Genre	Article	29
		Scientific article	3,5
		Interviews	11
		Descriptive texts	38
		Personal experience/opinion	9
		Info - advertisement	20

Finally, 16% of them include research issues or evidence, while 13% include historical information. In terms of the purpose of each document, in 43,5% of them medical purposes are involved, 40% aim to be conceptually informative, in 27% the socio-ethical issues on private stem cell banking are exposed, in 24,5**%** the scientific aspects are exhibited through the description of research experiments and finally a small percentage, 5,5% aims to expose the ethics of embryonic stem cell use. Finally, in 27% of the cases the documents are written by a journalist, in 19% by a researcher or doctor, in 14% by individual persons and in 13% by a stem cell bank's representative.

CONCLUSIONS AND IMPLICATIONS

Activities with media involved in the teacher education course seem to motivate student-teachers' interest and engage them in conversation with the scientific advances in stem cells as these appear in popular media culture. Their inquiry took place mainly through internet searches. Research issues or scientific articles are a limited proportion of their portfolios' documents. It is worth noting that the umbilical cord cell type is a dominant theme in the selected documents, while reports on other stem cell populations such as hematopoietic stem cells, neural stem cells, osteoprogenitor stem cells etc, which have also demonstrated potential for clinical applications, are limited. This in connection with the prevalence of references to the stem cell banks represents the widely spread public discussion on these issues in Greece and shows how the public media support and spread this discussion. This claim is supported by the fact that the aforementioned controversies are related mainly to socio-ethical issues on private stem cell banking, while the issue of ethics concerning embryonic stem cell use is almost absent.

The obvious purpose of these reports is to inform the audience of the medical benefits of stem cell research. The medical aspects play an influential role for the citizens as it is a sensitive issue for their lives and many studies have highlighted this tendency in students' understanding and discussions (Halverson et al, 2009; Halverson, 2011; Molinatti, 2011).

TABLE II			
Aspect		**Category**	**Percentage/ Frequency (%)**
Content of the document	What	Definitions	29
		Stem cell types	24
		Umbilical cord cells	38
		Properties	18
		Applications	45,5
		Research	16
		Controversies	33
		Historical information	13
		Stem cell banks	43,5
		Not focused	3,5
	Purpose	Conceptual/informative	40
		Research experiments	14,5
		Medical purposes	43,5
		Socio-ethical issues on private stem cell banking	27
		Ethics of embryonic stem cell use	5,5
Author/ Interviewee		Researcher/doctor	19
		Journalist	27
		Bank's representative	13
		Individual person	14
		Not stated	27

However, the hidden purpose is to persuade the readers about the importance of keeping the umbilical cord cells of newborn children. Parents face the dilemma of having to choose whether to avoid the high cost of stem cells banking and thus miss out on possible future benefits that their grown up children would have if they kept their umbilical cord stem cells during their birth. It is noticeable that in Greece the majority of stem cell banks are private, while the public services are not developed satisfactorily. The findings reveal that the public domain of science concerning stem cells in Greece is mainly dominated by stem cell private banks' sites, something that poses questions about the neutrality of such information. Of course science in the media is not at all like science in the textbook. It is shaped by media practice and codes of behaviour, influenced by commercial goals and the values of those who construct the news agenda and is responsive to the interests of the audience (McClune & Jarman, 2011). Moreover, it is shaped by local communities' goals, values, and priorities.

There is no clear evidence that student-teachers' critical media literacy has been developed to a satisfactory degree. Their engagement, however, with all this information has triggered an inquiry stance towards media information and its utilization for classroom learning and seems to support critical pedagogy. Moreover, through this design-research we discerned different aspects of student-teachers' involvement with media; this experience offers insight into how to guide student-teachers' use of the public domain of science more effectively in their learning about scientific advances and in using this information in their teaching plans. Their perception and attitudes with regard to this domain, as appear through evidence from the other activities they had to build, are significantly influenced by representations of scientific knowledge conveyed by the press and other mass media. Making the assumption that student-teachers' material may be a kind of representation of the information available on stem-cell issues in the Greek public domain, this article argues that the discursive reconstruction of scientific claims in the media is strongly entangled with social and commercial standpoints. Media information needs to be handled in a critical way by educators and teachers, as its neutrality is questionable. As Carvahlo (2007) claims, deciding what is scientific news, i.e. what the relevant “facts” are, and who are the authorized “agents of definition” of science matters is a crucial issue. The representation of scientific knowledge in the public domain has important implications for evaluating scientific applications in everyday life and teachers’ responsibility for the education of the critical faculties of each citizen is urgent. Awareness gained from the present research can lead to the further improvement of the module. Further experience is necessary in order to gain insight into how to guide student-teachers’ use of the public domain of science more effectively in their teaching.

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"ASPECTS OF TECHNOLOGY" IN SCIENCE FICTION TEXTS – SCIENCE FICTION IN SCIENCE CLASSROOM: AN EMPIRICAL STUDY

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Abstract: This study refers to the research conducted with primary school students examining whether they can identify the issues raised by the ethics, moral and political aspects of Technology through analyzing science fiction texts (short stories). In addition, we examine whether they can write science fiction stories of their own raising the above mentioned issues.
The research was conducted with a sixth-grade primary school class of 22 students over a period of six weeks in two-hour sessions, where students read and analyzed science fiction short stories and wrote science fiction stories of their own.
Our data (worksheets and science fiction stories by the students) were analyzed with Qualitative Content Analysis. Our analysis shows that the students can identify the elements of the text referring to the positive and negative aspects of Technology concerning the ethical and moral issues related to society. The students are at ease writing science fiction stories in which societal, ethical and moral aspects of Technology are presented, especially, as far as the use of Technology in the solution of environmental problems is concerned.

Keywords: science fiction, critical considerations (deliberations) of technology

INTRODUCTION

This study refers to the research conducted with primary school students examining whether the students can identify ethical, moral and political issues related to Technology raised in science fiction texts.
Science fiction texts were chosen as their plot often involves Science and Technology, as well as the impact that these have on society and the environment. The extrapolation of the "what if…" of science fiction texts does not violate scientific principles, but relies on them to guide thought experiments through to possible consequence (Czerneda, 2006).This process makes us concerned with current technologies enabling us to observe the possible manifestations of scientific progress and to experience and appreciate the many ways this may impact upon society and environment (Stavrou & Skordoulis, 2008). It can also serve as a focal point for discussion about our attitudes, perceptions, hopes and fears about Science and Technology (Berne, 2008). Additionally, science fiction texts highlight the ethical and policy issues raised by Science and Technology and provoke controversy and debate about possibilities and ramifications for humanity. The narrative elements of science fiction literary genre are used in the discourse of Science and Technology to bridge the gap not only between what is technically possible today and its inflated promises for the future but also to probe into the ethics about Science and Technology. Thus, science fiction could be used as a tool with which students might navigate the ethical and societal dimensions of technological terrain (Berne, 2008, Miller & Bennett, 2008). At its most powerful, science fiction has the potential to be not just story-telling but an inquiry into the human dimensions of technological futures

(Miller & Bennett, 2008). Thus, can take advantage of the popularity of science fiction to engage students more broadly in deliberations about technology (Miller & Bennett, 2008).

As Deery argues science fiction performs “a vital social function, which is to offer a testing ground, a thought experiment, where the social consequences of Science and Technology can be extrapolated in an intuitive, holistic and empathetic manner”, thus offering “humanistic-cultural” as well as political dimensions to Science Education (*as cited* Dritsas, 2007). Moreover, as science fiction is so often taken to be the expression of political opinion or ideology of the scientific and technological society aimed at presenting alternatives to social condition, it functions as thought experiment and critical discourse which can also bring more skepticism about politics, ideologies and epistemological certainties in the context of Science Education (Gough, 2006, Griffiths, 2009, Weinstein, 2009). This new socio-literary techniques, inspired by science fiction could offer significant contributions to the governance of new and emerging technologies by improving the capacity to reflexively assess the social dynamics of socio-technical systems (Miller & Bennett, 2008)

This study is a part of a wider research project whose main aim is to examine the way science fiction texts can be used as supplementary educational material in a cross-disciplinary context in primary school (Stavrou & Skordoulis, 2008, Stavrou & Skordoulis, 2010).

METHODOLOGY

Due to the fact that this study is part of a wider research project aiming at examining whether science fiction texts targeted at adult readers could be used in the context of educational process in primary school, we designed and conducted the following Case Study.

Case Study Protocol

Research Questions

• Whether students can identify the ethical, moral and political issues related to Technology raised in science fiction texts.

• Whether students can write science fiction stories, in accordance to science fiction conventions, raising the above mentioned issues.

Sample

The research was conducted with a sixth-grade primary school class of 22 students (12- year olds). The majority of them came from high-income and high education families.

Our research, consisting of six two-hour sessions, covered a period of six weeks in a cross-disciplinary context.

Implementation

Firstly, students were asked to articulate definitions of science fiction. Then, they discussed upon science fiction definitions given by the critics of the genre and they were asked to identify the elements unique to the science fiction genre according to these definitions.

Thereafter, students read and analyzed the following science fiction short stories:

«Memorial» (1946) by Theodore Sturgeon

«The King of the Beasts» (1964) by Philip Jose Farmer

«The Dragon XXXX» (1960) by Stanislaw Lem

«Computer Virus» (2001) by Nancy Kress

The above texts were chosen on the basis of the following criteria: a) they were written by acclaimed and awarded science fiction writers b) they refer to socio-scientific controversial issues and, in particular, to contrasts and conflicts or different approaches emerging from

different speculations on technological advances c) Science and Technology are depicted as human activities interacting with society.
Having read and analyzed each text, students had to work on a worksheet on the “scientific context” of the text, as well as the characters, their actions, the facts and the plot. The worksheets were designed in order for students to study not only the basic elements of the story, such as the theme, plot, setting and conflict, but also to highlight any technological, societal and/or ethical, moral and political issues as well as Technology versus society issues that were raised in the stories.
In the next stage, students were asked to write their own science fiction story according to particular instructions, in order to examine whether students were able to write science fiction stories of their own and, at the same time, whether they were able to raise the above mentioned issues in their stories. The science fiction story was assigned as an individual homework task. Finally, the students were asked to evaluate their own stories by use of a questionnaire, in order to become aware of the ‘scientific context’ of their stories.
Our data (worksheets and science fiction stories by the students) were analyzed in accordance with Qualitative Content Analysis.

RESULTS

Worksheets

The students were able to identify the elements of the text referring to the positive and negative aspects of technology concerning society and the environment. The majority of them mentioned the ‘dual use’ of Technology. For instance, when analyzing the “Memorial” text, the majority of them focused on the use of Nuclear Power for peace and its military use (nuclear weapons). They also mentioned the problem with nuclear waste even when it is used for peace. It is worth mentioning that a majority of them associated the military use of Nuclear Power and Technology with politics.
Moreover, they focused on the dilemmas faced by the scientist characters of the stories concerning the impact of the use of Technology (Nuclear Technology or Biotechnology).
Another point of focus was on the ethical and moral issues regarding the applications of Technology. In particular, when analyzing the text “The King of the Beasts” the students questioned the ethical or moral right of the scientists to clone a human being or even an animal. On the other hand, in both the stories “Memorial” and “King of the Beasts” the students articulated the view that only a scientist could deal with ethical and moral issues concerning Science and Technology just because *“he is a scientist”*, that is, a special human being.
In addition, they associated the use of Technology to matters of politics and power. In the text “The Dragon XXXX” the majority of them focused on the use of Information Technology and Computer Technology for world domination on behalf of politicians. Moreover, they were able to identify the positive and negative aspects of Technology as well as the impact of Technology on society, even when the text dealt with subjects the students were not familiar with.

Science fiction stories written by the students.

The students were able to write short science fiction stories of their own, in accordance with the genre’s conventions. Despite the fact that they found it difficult to elaborate on the dilemmas faced by the scientist characters of their stories they were able to write about the

variant aspects of Technology as well as the impact of Technology on society and the environment.
In several students' stories Technology was used in the solution of environmental problems, or in many cases, in the solution of problems faced by society (the hole in the ozone layer, cleaning the polluted seas, medication for the poor).
In addition, in several stories there were concerns about issues relating to ethical and moral aspects of Technology, as in the case of stories where cloned or mutated humans or even robots revolted against Technology itself.
Ultimately, in all stories the main character was a scientist, being the only person capable of giving solutions to any kind of problems.

CONCLUSIONS

Although the students were not familiar enough with written science fiction, they were at ease differentiating and identifying the ethical, moral and societal aspects / issues of Technology, especially when presented with texts referring to subjects familiar to them, such as Nuclear Power, Biotechnology, or texts in which the main character was a scientist.
As far as their own stories are concerned, the belief that Technology can be used in the solution to any problem faced is expressed in all stories. Moreover, the image of the scientist who has the ability to deal with and find solutions to all problems or issues prevails in all of them.
Because of their engagement with science fiction texts students were able to ask where humanity could possibly be led to with Science and Technology, and how these might affect the social, moral, and environmental conditions of human life. Thus, science fiction could be used, in order to enhance Education for Values, in Science Education.

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UNIVERSITY STUDENTS' DECISION-MAKING ON AN ENVIRONMENTAL PROBLEM

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Abstract: This paper shows the results of discussions of university level students who worked in small groups during the decision making process on an open-ended environmental problem. We have studied the decision making process of each group bearing in mind the steps of the normative framework. The process undertaken by one of the groups stands out as the students are capable of changing their initial option after having born in mind a criterion contributed by a companion and that had not appeared initially. This opinion has been decisive in evaluating the different alternatives and has been key to the change of position of various components of the group, something that is not usually the norm. We have also considered the difficulties another group had coming to a decision, as they could not deal with the disadvantages that all alternatives showed. It is concluded that the normative framework is a powerful tool which can help students in their approach to decision making using pre-formulated steps.

Keywords: Decision making, open-ended socio-scientific problems, environmental education

BACKGROUND, FRAMEWORK AND PURPOSE

Admitting that to educate for a change in society is one of the goals of Environmental Education, and that dialogue, negotiation and consensus are the basic mechanisms for the resolution of the conflicts, the development of action competences of our students will imply learning these procedures.

Training in the analysis of socioenvironmental conflicts, in the debate of alternatives and in the argued decision making for their resolution are, therefore, some of the goals to prepare our students for social transformation. From the point of view of environmental educators, we are interested in analyzing the communication established in the classroom to identify the learning processes and its obstacles.

During these last two decades the research based on the analysis of the decision making and the argumentation on socioscientific issues have increased and have diversified as regards the object of study, since now besides contents or scientific aspects, they appear other series of dimensions like social ones, psychological ones, ethics and pedagogic ones and, also, investigations in which the quality of the argumentation produced is evaluated and investigations to find the way of designing environments that favour argumentation.

RATIONALE

The process of decision making on open-ended socioscientific problems followed by students has been investigated from diverse points of view. We will comment those who have analyzed the process comparing it with normative frameworks (Kortland, 1996; Ratcliffe, 1997). According to these frameworks the first step implies assuming the task of taking the decision, next bearing the different options in mind, establishing criteria, seeking for information to evaluate the alternatives and, finally, making a decision (Janis and Mann, 1977).

But in everyday life it seems that we usually do not follow these steps, and we somehow start to evaluate the options at the same time that we put them on the table and we even, on some occasions, make the decision at the beginning of the process, which biases the subsequent process, since we tend to take into account only the information that supports the decision taken.

Ratcliffe (1997) developed a normative framework of several steps that made her students follow to decide on several situations. As Kortland (1996), she concluded that the students were in fact evaluating the alternatives while they were identifying the criteria that would guide their choosing process.

With this work we try to know how is the groupal decision making process of university students referring to a normative framework modified from Janis and Mann (1977), and studying if the students establish initially the criteria that will guide their process or follow a process biased by an option taken beforehand on an environmental decision making task.

METHODS

The design of this investigation is based on a similar study conducted with secondary students (Jiménez-Aleixandre, Eirexas and Agraso, 2006), who were presented with a case in which they needed to decide upon a heating system, basing this decision on economic and ecological criteria. In our own design, subjects were presented with the same problem: we had students select a heating system from among five possibilities without providing them with selection criteria. In addition, we developed a 23 pages dossier, containing information about the characteristics of the different energy sources, the environmental problems of their use and various data about the economic costs and emission of gases and particles. Besides, the students had six articles about the same issues. We tried to make this dossier as complete as possible, since it would be the most important source of information that would be available to the students.

The study took place in one section of the elective course 'Environmental and informal education' in the Social Education degree programme over the course of four 1½ hour sessions in May, 2004. The first three sessions were dedicated to cooperative work in small groups that involved reading the information and making decisions and the fourth session was dedicated to sharing results.

25 students participated (23 women and two men). Subject ranging in age from 18 to 23 years old were divided into the four groups.

We based this design on the idea of forming learning communities (Brown, 1992). Since students were placed in small groups to work together, they helped each other to learn. Furthermore, students who work in groups tend to demonstrate more positive attitudes and increase their self concept for the study when compared with students who are not grouped, demonstrating numerous changes associated with the establishment of collaborative learning environments (Oliveira and Sadler, 2008).

At the beginning, we simply gave each group a handout describing that their mission was to decide upon a heating system for a future building from among the options of diesel oil, natural gas, propane, bio-mass and electricity. Once the students offered their initial opinions, they were provided with the informative dossiers.

The first three sessions were audio-recorded and the fourth was video-recorded. Each group also generated reports in the form of session diaries, which were also collected.

The research falls within the interpretative methods of research (Erickson, 1986) that try to interpret the meaning actors give to their actions. The first author was the teacher of the group, and she and the second author were participant observers during the task. The results presented here are based on the oral discussions of three groups during the three first sessions as they arrived at a decision concerning the selection of an energy source. The transcript of the fourth group's discussions was lost due to technical issues. Students have all been assigned gender-appropriate pseudonyms. The pseudonyms assigned to Group A students all begin with the letter 'A', those of Group C students begin with 'C' and those of Group J students begin with 'J'. Group A was composed of six women, Group C consisted of four women and one man, and Group J included six women and one man.

The first step in the normative framework taken as reference consists of discussing the different solutions for a problem. In our case, as these options were determined in the task, this step was not taken into account. To make the analysis, we read all the statements (interventions) made by the students and we differentiated those that were related to the decision making process and those that were not. Then we proceeded with the identification and categorisation of the interventions related to the decision making: developing criteria, searching for information, evaluating alternatives and decision making.

In order to validate the identification and categorisation of these interventions, the two first authors conducted the analysis of Group A together and the analysis of Groups C and J separately and compared the results, reaching a 90% of agreement. The disagreement were discussed until a consensus was reached.

RESULTS

Initially, before having any information, all three groups opted for natural gas, although they admited that they needed more information to make a more informed decision. Table 1 presents the percentage of interventions dedicated to the different steps in the process of taking a decision in the three groups.

As can be seen, Group A dedicated a high number of interventions to the proposed task, especially to the evaluation of alternatives. Some members modified their initial choice based on the information provided in so far as they presented two different positions within the group (two support electricity and four natural gas), trying to persuade each other.

What happens is that one student supporting electricity (Arrate, line 533) refutes other student´s justification by saying they have to take next generations into account, which we have interpreted as using sustainability as a criterion (Uskola, Maguregi and Jiménez-Aleixandre, 2010).

532	Ainara:	(…) I also choose natural gas, (…). Natural gas is more cost efficient, more comfortable and well, although there are few resources, well, damn, there are still years left, right? And that's it, well, I don't know.
533	Arrate:	It's that, don't just think about the years that you're going to be here, think about those who will come later.
534	Ainara:	Sure but...
535	Amaia:	Sustainable development

From this time foreward the two options are evaluated on the basis of this criterion, leading three more students to support electricity. We could say that at individual level, students changing their mind followed the normative framework, while the students that where previously defending electricity don´t, as they have raised a criterion that falls in line with the decision they have already taken. These different individual results in Group A may arise because the normative framework usen by Kortland (1996) and Ratcliffe (1997) is quite linear and valid for one individual. We consider that this process that individually gives different interpretations, constitutes a good groupal process, as it has been the group who has created a criterion beyond the available information and who has adopted that criterion as a keystone in the process.

It is not usual that students change their mind during the process, as they usually take into account the information that fits with their choice (Kortland, 1996). Nevertheless, Jiménez-Aleixandre and Pereiro-Muñoz (2005) and Simonneaux (2001) found changes and evolutions in choices of students discussing socioscientific issues. In this case, the change has been produced by the introduction of a new and unexpected criterion, showing the seriousness of approach of the group on the proposed task, and also the open-mindedness of the students that change their mind by considering a criterion that did not favor their option.

The decision making process in Group C fits the normative framework. Since the initial stages of the task they hold that they do not want to contribute neither to the depletion of the natural resources nor to an increase in social differences. They search for information and evaluate the alternatives in the basis of the agreed criteria until they make their decision.

84	Carmen:	(*with respect to fossil fuels*) So these three pollute a whole lot. Well, at the moment we don’t like these, right?
85	Coro:	Right, but we don’t like…
86	Carlos:	… a level that is ecological
87	Carmen:	And economic level?
88	Carlos:	Well
89	Carmen:	And at a social level

The process of Group J is quite different. It is noteworthy that until intervention in line 779 (among a total of 799) there is not a choice to support one of the alternatives, as they discard all of the options when they know about their disadvantages. Group J is the one that dedicates less time to the task (Table 1) and they continuously complaint for lacking information to make the decision.

489	Jesica:	But biomass sounded us fantastic, but then...
490	Jon:	Solar panels.
491	Jesica:	But then we realized about disadvantages we discarted … Maybe biomass.
492	Julia:	We lack information.

This is a situation found also in other investigations (Hogan, 2002; Kolstø, 2006) and named *defensive avoidance* and that can be interpreted as not even taking the commitment to make a decision, a previous step to start the process (Janis and Mann, 1977).

Steps of the Decision Making Process	Group A %	Group C %	Group J %
1- Developing criteria	1	2	1
2- Searching for information	20	21	34
3- Evaluating alternatives	49	36	4
4- Decision making	5	10	4
Total	75	69	43

Table 1: Proportion (percentage) of interventions dedicated to the steps of the Decision Making Process.

CONCLUSIONS AND IMPLICATIONS

It should be noted that the students who took part in the study show a high decision making competence, demonstrated by their willingness to consider the advantages and disadvantages of the alternatives and their requirement of having information available before making a decision (Ratcliffe, 1997). This can be related to the age and maturity of the students. Besides, they show a high level of commitment to the task, dedicating a high proportion of their interventions to the decision making process.

It is noteworthy to highlight that none of the three groups has mantained their first choice, natural gas. This draws us to the conclusion that both the available information as well as the interactions among the students have been key and more important that the previous preferences, which would fit to some extent to the «*valence distribution model*» sociologic theory, confirming Aikenhead (1989) hipothesis in that in the cases of group decision the most important factor to consider is the discussions among the groups. We consider noteworthy the fact that the option changes of the members of one group are due not only to new information but also to the introduction of a new criterion by one student which was not previously taken into account.

On the other hand, it is worrying the situation in one of the groups that can not cope with the fact that there is not a perfect solution, that all of them have disadvantages. We think that there are several things we could do in a future activity to prevent this situation. One is to use the potentiality of the normative framework (Kortland, 1996) making students more conscious of the steps they should follow. Another one is to work with students about more authentic situations in which the intrinsic uncertainty and complexity of science and everyday life arise.

Although we acknowledge the limitations of this study, we think that this kind of learning contexts can favour the development of decision making competence and critical thinking, recognised as important objectives of science education in the Budapest Declaration (UNESCO-ICSU,1999) and more recently in the OCDE Pisa Project (OECD-INECSE, 2006).

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PART 8: ENVIRONMENTAL, HEALTH AND INFORMAL-OUTDOOR SCIENCE EDUCATION

Co-editors: *Miriam Ossevoort and Graça Carvalho*

Ecological and Environmental Education, Education for Sustainable Development, environmental health, health education and health promotion. Lifestyles and attitudes towards health and the environment. Developing and evaluating the impact of programmes and experiences outside classrooms, including those organised by institutions other than schools.

This part corresponds to strand 8. It contains 29 papers.

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ENVIRONMENTAL, HEALTH AND INFORMAL-OUTDOOR SCIENCE EDUCATION

THE CONTRIBUTION OF "POPULAR" BOOKS TO THE INFORMAL LEARNING OF CHEMISTRY

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Abstract: This study aims at identifying and categorizing books based on chemical ideas for a general audience, at analyzing the text understanding and interest in the themes covered in the book by a non-specialist audience, and at identifying characteristics of the text that can enhance reading with comprehension for that group of individuals. In order to attend to these aims, the catalogues of 59 major publishers, publishing books in Portuguese and English, were searched and 145 books currently available in the market were identified. These books were then grouped according to their themes. In addition, 17 students, with no extensive background in science, were invited to select a book from one of the categories, to summarize it, and to evaluate it using a general framework provided to them. Results show that most of the books are about "biographies of chemists" or about "particular chemicals", and that readers became interested in some themes covered by the book. An overall understanding of the text was not achieved; in particular, aspects concerned with nature of science were not understood. The readability of the books was constrained by features of the text.

Keywords: books for general audience, comprehension of text, informal science education, learning of chemistry.

INTRODUCTION

"Popular" chemistry books: a partway to chemistry literacy

Chemistry is embedded in all aspects of life; from food preparation, cosmetics, cleaners, and waste disposal to textile preparation. Although the idea of "chemical-free" life is a myth, several misconceptions about what chemicals are and do are spread among citizens (e.g. chemicals are unsafe, cause pollution, and can be avoided by special diets and soaps, synthetic chemicals are causing many diseases) and influence their decisions about health, lifestyle and social policies (Hartings & Fahy, 2011). Consequently, there is a need to improve the levels of chemistry literacy among citizens so that they can move from lower levels of chemical literacy, in which chemistry can inform proper decisions in daily life (i.e. practical literacy), to higher levels of literacy in which individuals can participate in social debates involving chemical sciences (i.e. civic literacy) or appreciate chemistry as a major intellectual activity (i.e. cultural literacy) (Shwartz, Ben-Zvi, & Hofstein, 2006).

Informal chemistry education plays an important role in engaging citizens with chemistry, in particular adults who are no longer in the educational system. Informal chemistry education can be characterized by being voluntary, learner-led, non-assessed, and covering a diversity of contents. It can also be promoted in different settings, ranging from science museums, television, Internet to print. These modes of communication have been successful in engaging and educating citizens in science broadly. However, in some of these informal settings, such as television or science museums, few chemistry ideas are covered. Print has been one of the main modes of communication used by USA adults to engage with science (Masciangioli, 2011). In particular, in the last thirty years there has been a publishing boom of science books for a non-specialist audience (Turney, 2001). Yet, the role of these books in promoting scientific literacy, in particular chemistry literacy, is unclear due to a lack of systematic studies focusing on this mode of communication.

Chemistry books for non-specialists can be called “popular” chemistry books. They can be defined as books based on chemistry ideas, printed in a large scale for a general audience who are interested in improving their understanding of a particular theme and in being entertained at the same time. General guidelines have been proposed for writing “popular” chemistry books so that they can have an impact on improving chemistry literacy (Emsley cited in Masciangioli, 2011): choose a topic being that is something new, something that answers previous problems, something that overturns beliefs, something that impacts people’s lives; avoid of technical terms but if they are necessary they need to be explained; avoid chemical formulas; neither overestimate the public’s familiarity with the topic nor underestimate their intelligence; include human interesting information; and make chemistry visible by giving it a critical role in stories.

Reading with comprehension

A text can be processed at two different modes: either as a set of propositions (i.e. a description of a text itself, retaining its structure) or as a mental model. Reading with comprehension requires constructing a mental model of what the text is about. A mental model of a text is an adequate mental representation of the elements of the text (e.g. events, states, objects, and protagonists) and their relations (e.g. causal, temporal, and logical) that are explicitly mentioned or that can be inferred from the text. A model of a text is personal, is guided by the reader’s goals, is continuously updated and constructed during reading, and corresponds to an interpretation of a particular text in a particular moment (Kintsch & Rawson, 2005; van Dijk, 1995). Thus, a mental model of a text is a representation of the situations described by a text, rather than a description of the text itself.

Constructing a mental model implies the simultaneous activation of top-down (e.g. retrieval of prior knowledge) and bottom-up (e.g. recognition of “data” from the text) processes. This is an easy task for skilled and knowledgeable readers but a problem solving activity for non-skilled or less knowledgeable readers. For the former readers, top-down processes ensure that text information, consistent with their prior models and expectations, is integrated in their mental structure; while the bottom-up processes call the readers’ attention to novel information. It is expected that skilled and knowledgeable readers can not only select, synthesize and organize the main ideas in a coherent summary (i.e. provide an overall understanding of a text) but also build a mental model that goes beyond a literal interpretation of the text by making predictions, mental imagery, and creating links with prior experiences. For less knowledgeable readers, the activation of prior knowledge is poor and inferences from the text are difficult to perform. This results in a superficial integration of the new information into their existing mental structures. In an extreme situation, top-down processes may dominate reading, resulting in inferences based on prior guesses, oversimplifications and processing of irrelevant information. Consequently, misreading will occur and an inadequate mental model will be created (Adams, 1980; Kintsch & Rawson, 2005).

In this constructive process of meaning, different factors influence the readers’ processing of a text, namely (Irwin, 1983):

- the reader's individual characteristics: Who is reading? Attends to the reader's prior knowledge about the topic, emotional attitudes towards the topic and the reading task, and reading skills;
- the reading material itself and its individual characteristics: What is being read? Refers to micro-structural features (e.g. world familiarity, sentence length, inter-sentential coherence); macro-structural features (e.g. summaries of the main points clear organizational pattern of the text, form of the text – expository, narrative,…); and elaborative features (e.g. analogies, pre and post-reading questions, examples);
- the situational characteristics: Why, when and where are they reading? Concerns the purpose of the reading task and the social, emotional and physical environments.

A major challenge consists in finding an appropriate match between the reader and the reading material. The reading material is a channel of communication between the writer and the reader and writers need to take decisions on the form and content of the text by making considerations on a given audience. In the light of the literature, this study aims at:

- Identifying and categorizing the "popular" chemistry books that are currently available in the market
- Analyzing the text understanding and interest in the themes covered in the book by a non-specialist audience
- Identifying characteristics of the text that can enhance reading with comprehension for that group of individuals.

METHODOLOGY

In order to identify and categorize "popular" chemistry books currently available in the market, the abstracts of "popular" chemistry books, published in English or Portuguese, were searched in the catalogues of major publishers. 145 books, identified in 59 publishers, were then grouped according to their main themes. In addition, 17 undergraduate Portuguese students of education with no extensive background in science were invited to select a book from one of the categories of books created, to read it from cover to cover, to provide a summary of the texts and to evaluate the books. The readers' choices were confined to books published in Portuguese. Yet some of them were translations of books originally written in English or French. Since situational characteristics affects reading outcomes, a list of general aspects that students should have in consideration when evaluating the books were provided to them. These aspects, based on the literature on text comprehension, include: the interest and the appeal of the book; the chemical ideas included in the book; the relevance of the information provided; specific features of the text; the overall written style; and the way chemical knowledge is produced. In addition, 11 students, who produced unusual or incisive evaluations, were interviewed. The data from the books' evaluation were analyzed by using the literature on "reading with comprehension" as a framework.

RESULTS

Popular chemistry books

As can be seen from Table 1, most of the books were published in English, most of the authors were male, and most of the books are included in the categories "biographies of chemists" and "particular chemicals". Although less frequent, some books fit into the categories "chemical cookbook/hands-on chemistry", "foundation ideas in chemistry", "fiction with an emphasis on chemistry", "use of chemistry in other disciplinary fields", "history of developments in chemistry", and "chemistry in everyday life".

Table 1: The language of publication, authors' gender and categories of "popular" chemistry books (n=145)

"Popular" chemistry books		f
Language	Portuguese	36
	English	109
Author's gender	Female	22
	Male	123
Category	- Chemical cookbook/hands-on chemistry: describe phenomena and reactions that can be safely explored by readers	4
	- Foundation ideas in chemistry: deal with the core ideas of chemistry	9
	- Fiction with an emphasis on chemistry: present chemistry embedded in a fictional story	9
	- Use of chemistry in other disciplinary fields: discusses the contribution of particular chemistry ideas to research and development of other disciplinary fields	10
	- History of developments in chemistry: conveys how chemistry emerged and developed over the years	17
	- Chemistry in everyday life: emphasize the contribution of chemistry in daily life and social life	18
	- Biographies of chemists: recount the life and time of a chemist and his/her contribution to chemistry	38
	- Particular chemicals: focuses on the chemistry, applications and implications of particular substances and chemical species	40

Comprehension of the text and factors affecting it

In spite of the diversity of titles of the books selected by readers (Table 2), the data show that reading with comprehension was a difficult task for them (Table 3). Most of the readers' summaries of the books are descriptions of the text itself or parts of it, maintaining the structure of the book in their summaries. Few readers (two) built mental models of their texts, and they only reflect an overall understanding of the text. Thus, for the majority of the readers, the reading process seems to have been restricted to decoding of individual idea units and sentences (Irwin, 1993).

Issues on the nature of chemistry (NOC) were not valued and understood by readers. Their views on NOC reflect fragmented and naïve understanding of scientific enterprise and scientific inquiry, as the following example illustrates:

> "Experiments in chemistry result from observing the world. They are the grounds for building theories which are sometimes incompatible. Sometimes, scientists steal researches from their peers. This book mentions the pressure that scientists feel to publish. However, in order to publish scientists need to submit their papers to peer review" (Reader 2, *Water*)

Two reasons may explain this finding: readers may hold strong misconceptions about the theme, and aspects on the NOC are scattered along the text and not explicitly mentioned. The former reason may guide readers to select only the information presented in the text that support their beliefs on NOC. The latter reason may restrict the readers' opportunities to critically reflect on their views on NOC and to move towards acceptable conceptions, due to their difficulty in selecting, synthesize and organize the main ideas in a coherent summary.

Table 2: Reference of the books selected by readers in each category

Category	Reference of the selected books
Chemical cookbook/hands-on chemistry (2 readers)	Mateus, A. (2001). *Chemistry in our head: Spectacular experiences that you can have at home* (Química na cabeça: Experiências espectaculares para você fazer em casa). Minas Gerais: UFMG
Foundation ideas in chemistry (2 readers)	Atkins, P. W. (1995). *The Periodic Kingdom: A Journey into the Land of the Chemical Elements*. New York: Basic books. Laszlo, P. (1995). *A palavra das coisas ou a linguagem da química* (The word of things or the chemical language). Lisbon: Gradiva
Science fiction with an emphasis on chemistry (1 reader)	Djerassi, C. & Hoffmann, R. (2001). *Oxygen: A Play in 2 Acts*. Weinheim: Wiley-VCH
Use of chemistry in other disciplinary fields (2 readers)	Bourre, J. (1993). *Comida inteligente: A Dietética do Cérebro*. (Clever food: The diet of the brain). Lisbon: Gradiva Watson, J. (1980). *The Double Helix: A Personal Account of the Discovery of the Structure of DNA*. New York: W.W. Norton
History of developments in chemistry (2 readers)	Laszlo, P. (1996). *A nova Química* (The new chemistry). Lisbon: Instituto Piaget Pimentel, G. (1998). *Oportunidades em Quimica – Hoje e amanhã*. (Opportunities in Chemistry: Today and Tomorrow). Lisbon: Sociedade Portuguesa de Química.
Chemistry in everyday life (2 readers)	Schwarcz, J. (2001). *The Genie in the Bottle: 67 All-New Commentaries on the Fascinating Chemistry of Everyday Life*. Toronto, ON: ECW Press Escoval, M. T. (2010) Acção da Química na Nossa Vida (Chemistry in our life). Lisboa: Presença.
Biographies of chemists (3 readers)	Filgueiras, C. (2007). *Lavoisier e o estabelecimento da química moderna* (Lavoisier and the contemporary chemistry). São Paulo: Odysseus Levi, P. (1994). *The periodic table*. New York: Schocken books Oliver S. (2002). *Uncle Tungsten: Memories of a Chemical Boyhood*. New York: Alfred A. Knopf
Particular chemicals (3 readers)	Aldridge, S. (2001). *Magic molecules: how drugs work*. Cambridge University Press. Ball, P. (2000). *Life's Matrix: A Biography of Water*. New York: Farrar Straus & Giroux Colborn, T., Dumanoski, D. and Myers J. P. (2010). *Our stolen future: How do we disposal chemical synthetic substances – our fertility, intelligence and survival*. New York: Penguin

Table 3: Readers' comprehension of the text (n=17)

Comprehension of the text	f
Bellow descriptive mode	2
Descriptive mode	13
Mental model mode	2

Several features of the text were pointed out as enhancing understanding. They include: 1) elaborative features, namely illustrations of mechanisms or drawings; analogies that employ familiar analogues; and adjunct questions; 2) macrostructure features, such as presence of sub-headings; and 3) microstructure features, particularly explanations of scientific vocabulary (Table 4).

Table 4: Comments on features of the text that were perceived as affecting understanding

Comments	Aspects mentioned and examples of response
Elaborative features (n=23)	• Illustrations “The images helped me to understand the descriptions presented in the text, allowing a more concrete idea about the objects that are mentioned.” (Reader 13, *Oxygen: A Play in 2 Acts*) • Analogies “There are some analogies that support comprehension. For example ‘a living organism is like a chemical factory’ (Reader 14, *Opportunities in chemistry: today and tomorrow*) • Adjunct questions "Questions are also present in the majority of the chapters, which is useful because they hold the readers’ attention, involving them with the text and leading to self-questioning.” (Reader 15, *Our stolen future: are we threatening our fertility, intelligence, and survival?)*
Macro-structure features (n=27)	• Sub-headings “The book organization around themes and sub-themes contributed for organizing mentally the information understood for each theme.” (Reader 4, *Magic molecules*: *how drugs work*)
Micro-structural features (n=10)	• Scientific vocabulary explained “The author provides several definitions that enhance understanding, e.g. on p. 51, the author says that: ‘I found a huge demijohn of technical benzene, at 95 percent purity. Manuals prescribed rectifying it and then putting it through a final distillation in the presence of sodium. To rectify means to distil it by fractions’ (Reader 10, *The Periodic Table*)

Interest in the themes covered by the books

Although sustained interest in the themes covered by the books was low, readers experienced motivation and interest in some sections of the books. Interest typically arises from reading a synopsis of the book that includes information about the importance of a theme and attends to reader’s interests and non-expertise on the theme. Interest in a given part of the book can then be raised, depending on whether or not the text matches the information provided in the synopsis; the themes covered are linked to reader’s concerns/needs/interests; and the author avoids specialist language. An example is:

> “The synopsis is appealing because it focuses on the fundamental aspects of the book and mentions that it is appropriate to the general public. It called the readers’ attention to the importance of reading the book without involving them in a scientific and complex reading. [After reading the book] I was interested to learn about some themes, i.e. recreational drugs or cancer. The theme “recreational drugs” was of interest to me because it is a contemporary theme that we face in our everyday life, mainly in clubs. Similarly, I was interested in the theme “cancer” because one of my family members suffered from that disease. On the other hand, in spite of the cutting edge research on the theme “gene-based medicine”, I was not interested in the topic. It is very complex and is not clearly related to my everyday life.” (Reader 4, *Magic molecules*: *how drugs work*)

CONCLUSIONS

The results of the study suggest that those who only read Portuguese will have restricted opportunities to develop their chemical literacy through “popular” science books, since these are scarce. There is a need to stimulate female chemists to write "popular" science books. Finally, more book titles on "fiction with an emphasis on chemistry", "chemistry in other disciplinary fields", and "chemistry in everyday life" are needed. Books on "fiction with an emphasis on chemistry" contain narrative, which is a key element in science communication (Stocklmayer & Gilbert, 2002); books on "chemistry in other disciplinary fields" and "chemistry in everyday life" can be successful in raising cultural and practical literacy.

For less knowledgeable readers, reading "popular" chemistry books with comprehension may be enhanced when they include: a) elaborate features (e.g. analogies with familiar analogues, drawings, illustrations of mechanisms, pictures, and pre- and post-reading questions); b) macroscopic features (e.g. sub-headings); c) microscopic features (e.g. explanations of scientific terminology). In addition, understanding NOC requires an explicit approach to the issue as already pointed out by (Khishfe & Lederman, 2007). Comprehension and interest are related (Irwin, 1983). Arising and sustaining the latter can be facilitated by including frequent and explicit links between the theme being addressed and the interests/needs/concerns of the readers, and by keeping a tied continuity between the synopses and the different parts of the book.

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BIOCENTRIC REASONING IN CHILDREN: IMPLICATIONS IN SCIENCE AND ENVIRONMENTAL EDUCATION

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Abstract: This study aimed to verify the incidence of biocentric reasoning (centred on the welfare of the animals) in 91 children, aged between 8 and 10, attending the 3rd and 4th years in a primary school of Lisbon, Portugal, and is the continuity of another study promoted by the authors. To do that, a questionnaire was applied, inquiring about the type of places where the children contact with animals and their opinion about the human behaviour in three different situations involving animals (dilemmas). The results have shown that the majority of children had a small contact with natural and semi-natural places, and the majority only went to places where nature is managed, like zoos and similar parks. This experience seems to be responsible for inappropriate ideas about zoos, considered by some children the ideal place to keep wild animals because there they are well treated and safer from predators. However, and globally, the incidence of biocentric reasoning in the dilemmas is high, proving its increasing in situations in which human action is considered selfish or inappropriate, but it also is affected by the species presented (the empathy factor seems to be important as well). Implications of these results for Science and Environmental Education are also discussed.

Keywords: Children-animals relationship; Ecological dilemmas; Anthropocentric reasoning; Biocentric reasoning; Ecocentric reasoning

FRAMEWORK

The interest for environmental issues in the last decades conducted to the affirmation of the environmental ethics field, where different theoretical works in the way Human-Nature relationship is conceived can be found. In a simple categorisation, these works can be inserted in one of the following perspectives: (1) Anthropocentric – centred on an instrumental vision of nature and defending the sustainable use of earth resources. However, it can also emphasise the contribution of nature to the integral development of the human being in both physical and psychological terms; (2) Biocentric – centred on the intrinsic value of the other beings, with a strong opposition to multiple ways of their exploitation. Because it includes different approaches, it can be limited or confined to the more complex creatures (mammals and birds) or extend the moral consideration to all life forms; (3) Ecocentric – centred on the intrinsic value of ecosystems, whose equilibrium is more important than the particular interests of each species, including the human. It can also emphasise a deeper connection between humans and nature where aggressions towards nature are seen as aggressions towards our species.

In another context, environmental issues also entered the curricula of different countries, in association, specially, with Science Education and Environmental Education. However, in the case of Portugal, the dominant pragmatic view has conducted to the implementation of activities considered apparently neutral and consensual, not reflecting the rhetorical diversity found in the environmental ethics field, and only implicitly transmitting an anthropocentric perspective of nature (Cachapuz et al., 2002; Almeida, 2007). The excessive focus of teachers' environmental projects on resources management, drawing attention to simple actions like recycling, buying environment-friendly products, saving water or switching off the lights when one leaves a room or on the improvement of the quality of school areas can be explanations for this situation (Almeida & Vasconcelos, 2011).

RATIONALE

Beyond the field of environmental ethics, the domain of Developmental Psychology has also been interested in the incidence of anthropocentric and biocentric reasoning in children and adolescents. Studies by Kahn (1999, 2002) employed an interview methodology including questions about children's knowledge, beliefs and values related with environmental problems and applied it to three different regions of the world – Houston (USA), Amazon (Brazil) and Lisbon (Portugal). The results were very similar and revealed a low incidence of biocentric reasoning that tends to increase with age and can coexist, in some cases, with anthropocentric reasoning, reflecting a broadening of the mental organisational structure of the human-being. Kahn also found a type of biocentric reasoning, designated compositional reasoning that reflects a more holistic view of the environment because it is based on the integrity, beauty and sense of balance of nature. Compositional reasoning, a kind of ecocentric reasoning, clearly increases with age, especially in adolescence, and seems to depend on a deeper understanding of ecological concepts.

Trying to explain these results, Lourenço (2006) considered that the cognitive potentialities of reasoning not centred on the human beings are not being explored by school. But Kellert (2005) referred a new trend in the modern world, of which, in fact, we don´t know the exact implications: the direct experience in natural and semi-natural places is declining and being substituted by an indirect experience in places where nature is managed by the human-being, such as zoos, aquariums and other similar places. However, a different approach can be found in a study promoted by Kortemkamp & Moore (2009). They concluded that the incidence of biocentric reasoning can be related with the way questions are formulated. Children, when confronted with situations where human action is considered selfish or unfair, improved significantly this way of thinking.

In face of very different results, Almeida et al. (2011) promoted a study with urban children (ages 8 to 10), using an interview methodology, confronting them with one real and two hypothetical dilemmas involving animals, and also wanting to know the type of places where they had already met animals. The real dilemma was about the slaughtering of seals because they included codfish in their nourishment; the hypothetical ones were about the capture of a hedgehog and a small fox in the wild carried into a backyard in an urban environment. This type of questions generated high biocentric reasoning, even considering that the contact experience with animals occurs mainly in places where nature is managed. However, the fact that some children argued referring their empathy for seals, seeing them as friendly animals, and that, at the same time, some others referred the danger for humans of capturing a young fox (which are both anthropocentric arguments), conducted to the new/complementary study now presented.

Methods

To verify, once again, if biocentric reasoning is affected by the way of questioning but also by the animal species in presence, a new but similar questionnaire was built, with a few changes in the species presented in the dilemmas. Table 1 contains the questions used in the questionnaire and also their nature.

Table 1. Interview questions and their nature

Number	Question	Nature of the question
1	Can you tell me places where you have met animals in freedom?	Question about experiential aspects of the child
2	Can you tell me places where you have met animals in slavery?	Question about experiential aspects of the child
3	From all the mentioned places, which one did you like the most? Why?	Question about child's beliefs
4	From all the mentioned places, which one did offer the best conditions for animals? Why?	Question about child's beliefs
5	The amount of codfish in oceans is decreasing. Some scientists discovered that some shark species eat this fish. To prevent the continuous decreasing of codfish we are thinking in a way of killing a higher number of sharks. Do you think it is a right or a wrong decision? Why? If for you it is a wrong decision, what other measure would you take?	Ecological dilemma in relation to a real scenario
6	A family went for a walk in a forest and found a tortoise. One of the members caught it and brought it to their backyard. Do you think it was a right or a wrong decision? Why?.	Ecological dilemma in relation to a hypothetical scenario
7	A family went for a walk in a mountain and found a young wolf. One of the members caught it and brought it to their backyard. Do you think it was a right or a wrong decision? Why?	Ecological dilemma in relation to a hypothetical scenario

In this new questionnaire, the seal was substituted by the shark (a less friendly animal), the hedgehog by a tortoise (a less complex animal) and the young fox by a young wolf (a hypothetically more dangerous animal). The questionnaire was piloted first with 6 children and then applied to a sample of 91 children (ages between 8 and 10), attending the 3rd and the 4th years in a primary school of Lisbon, Portugal. It was a convenience sample, like the one in the previous study cited, improved by the authors, because it was formed by pupils of 5 teachers that usually collaborate with initial training courses for new primary teachers. All the questionnaires were applied by the same researcher in each class and started with the explanation of its purpose, knowing their opinion about certain issues, and emphasizing that there would be no right answers. Then, each question was read aloud by the researcher, and a time was given to each child to answer it; only after that, the next question would be proposed. We tried to avoid answers impossible to codify due a misunderstanding of the questions. The answers were codified as anthropocentric - if centred on any benefit for the human-being (children include); biocentric – if centred on the interest of other living beings, and ecocentric – if it appealed, even subtly, to holistic relationships between natural entities. We decided to include ecocentric reasoning, excluded in other studies, even knowing that probably it will have a small expression, considering that it depends on the comprehension of ecological concepts, which normally occurs in adolescence. Some examples of examples gave by the children were included not only for a better understanding of their codification but also to show the diversity of the ideas propose by the children. In the transcription of their answers, Seidman´s (1998) recommendation was followed, as he considers that, to preserve

the dignity of the participants of a study, some orthographic and semantic corrections must be included.
The percentage of each type of answer was compared with the one obtained in the previous study and in the presence of dissimilar results a chi-squared test (χ^2—non-parametric statistics) was used with a 0.01 level of significance to verify the homogeneity between the two samples.

RESULTS

The results confirm the lack of contact of urban children with natural and semi-natural places, with more expression in this study, considering the number of children that didn't remember seeing animals in the wild. Even so, the incidence of biocentric reasoning was still high but influenced by the focus of the questions, as answers to questions 3 and 4 are a good example. In the first one, when expressing their preference for places where they had seen animals, anthropocentric reasoning was dominant, with arguments about the quantity of animals seen, the fun they had, or emphasizing the fact they saw their favourite animal; in the second one, when invited to assess the animal conditions in the places referred, the tendency inverted and biocentric reasoning was almost exclusive, with considerations about the value of freedom, being in their habitat and having food, good treatment conditions or being protected from predators when in captivity, especially when zoos were referred. In fact, this last argument shows that for some children zoos conditions are even better than those in the wild, undervaluing the authenticity of the places as a criterion for animal welfare.
Considering the three dilemmas proposed, biocentric reasoning was again the most frequent as in the previous study. In the case of the shark dilemma, the highest number of the children criticized the killing of sharks. They didn´t agree for different reasons like the following: –They are killing a fantastic species‖; –...because they are living beings‖; –It is not fair to kill them and keep all the cod for us‖ or –...because all animals have the right to live‖. Some reasons even reveal, in some way, embryo ecocentric ideas: –sharks are important in nature‖ or –...because without sharks, cleaner fish don´t have any work to do‖. However, comparing with the first study where a seal was used in the dilemma instead of a shark, biocentric reasoning has less expression. The use of the chi-square test revealed statistically significant differences between the two samples ($p. < 0.01$), which proves the importance of the empathy factor in this type of reasoning. Even so, the majority of children that disagreed with the sharks slaughtering gave biocentric alternative solutions. Some examples: –I think that fishermen should fish less. In fact, they are not helping to deal with the situation‖; –We should not kill sharks and eat more vegetables and fruits instead, which is healthier‖ or –I propose to reduce cod fishing and then cod can reproduce and we can fish it again‖. Even so, a few creative anthropocentric solutions were suggested: –My solution would be to put sharks in a zoo‖ or –I think we should give them something to make sharks fall asleep and then fish the cod‖.
Considering now the two other dilemmas, the change from the hedgehog to the tortoise and from the young fox to the young wolf didn´t affect the biocentric incidence of the answers. In the first case, most children considered a wrong decision to catch the tortoise from the forest. Some arguments were: –...because the tortoise was at its natural habitat‖; –The tortoise will be sad because it doesn´t feel at home and in freedom‖ or –...because it will lose its family‖. Even those children that agreed with the action revealed they were worried with the animal welfare: –it was a good decision because a car or a truck could run over it‖ or –they did right because in a backyard there are many leaves for the tortoise to eat‖. In the second case, the arguments were similar but with a high incidence on the importance of keeping the young wolf with its parents/mother, when comparing with the tortoise dilemma. Some examples of the different reasons given by the children: –they did wrong because animals have the right to

be free‖; –it was a bad decision because the wolf is a baby and needs its mother´s cares‖; –they did wrong because young wolves must be near their parents and mountains are the place where they should live‖ or –...because wolves are wild animals‖. However, like in the dilemma with the young fox presented in the previous study, the danger factor had similar expression, emphasizing the problems to humans caused, for instance, by the growth of the young wolf‖. Some examples: –they did wrong because the wolf can attack when it grows up‖; –the wolf can kill someone and it bites‖ or –wolves kill people and eat chickens‖.

CONCLUSIONS AND IMPLICATIONS

The results of the two studies promoted show that the majority of children in the final years of primary school[1] can reason in a biocentric way and a few also reveal some perception of the holistic function of nature. That allows peers discussions to its promotion in those that can only argue in an anthropocentric way. Considering this, and other results presented, a systematisation of some implications for Science and Environmental Education is possible:

-To promote outdoor activities in very different places (natural e semi-natural).

It´s important to increase the diversity of places where children can contact with animals. Because their experience seems limited to places where nature is managed, like zoos and similar parks, the contact with natural parks and reserves is an important complement, especially because it promotes the fortuitous contact with animals, helping children to recognize that this type of experiences has a much higher value than the contact with animals in cages or small places where no effort is made to see them.

-To discuss, in particular, the zoos conditions, and those of similar places, for a better understanding of the relation between animal welfare and the authenticity of these places;

This recommendation is related with the previous one. It is also important that teachers explore zoos, not only in a scientific dimension but also in an ethical one.

-To diversify the issues in classroom, including some controversial ones that deal with human-animal-nature relationship, like sportive hunting, human-diet and species extinction, for instance.

In fact, because children can understand non-human centred arguments, the confrontation of different ideas and perspectives about these subjects can promote an important cognitive development of students and a better understanding of the cultural, social, economical and ethical dimensions that they include.

-To discuss pets, domestic and wild animals' specificities for a better understanding of the needs of each group;

It's important to explore the real needs of the animals from the groups mentioned above. In fact, some misconceptions were detected in the children´s ideas, and these may be related with the limited contact with places where nature is managed.

-To approach the ecological role of each species, independently from complexity, aesthetics and empathy, which can help to overcome the bad reputation of several animals due to superstitions or legends, often making them victims of irrational human behaviour.

Some children revealed some exaggerated perceptions about the real danger of some species, particularly those with a predatory instinct. Therefore, some work must be done towards a better understanding of the behaviour of these species, making their danger for humans more relative.

NOTES

1. Primary School in Portugal includes the first four years of Basic School. The ages of children are, normally, between 6 to 10.

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FEEDING HABITS OF PRIMARY SCHOOL STUDENTS IN A RURAL AREA

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Abstract: Skipping meal is important for the health and development of children and adolescents. This paper reports the findings of a survey of 162 elementary school students concerning the extent of skipping a meal. Results indicated that 21.6 % of the sample usually skipped a meal. The reasons indicated for skipping a meal was loss of appetite, lack of time, inadequate pocket money and to lose weight. Parents should be informed and educated about the feeding problems of the students and encouraged to provide meal to their children.

Keywords: nutrition, breakfast skipping, feeding habits, primary school, rural area

INTRODUCTION

Nutrition problems of the school children affects their physical and mental development, thereby affects their education. Nutrition problems can arise from various factors that can range from malnutrition to irregular and excessive feeding. Various factors such as socioeconomic, genetic, cultural, environmental, level of education about nutrition, and family affects students' nutrition quality and their habits. Underdeveloped, developing and developed countries even if the nutrition problems are of different sizes, face with Nutrition-related problems. One of those nutrition related problems is skipping a meal, especially the breakfast skipping. Breakfast skipping is highly prevalent in the United States and Europe (10% to 30%), depending on age group, population, and definition (Rampersaud, Pereira, Girard, Adams & Metzl, 2005). There are various factors of skipping the breakfast some of which are lack of time, diet, not being hungry in the morning (Shaw, 1998). According to Randler and Frech (2009) some of the students sleep late and they therefore find it difficult to get up in the morning, and they leave home without breakfast, but eat on the way to school, at school (Randler & Frech, 2009), or do not have at all. Therefore, breakfast skipping is an important problem associated with health and school functioning, because, without breakfast, school achievement and cognitive functioning may decrease (Shaw, 1998; Pollitt & Mathews, 1998). According to Randler and Frech (2009) breakfast skipping causes students to work at school with sub-optimal nutrition. They also have reported that in Germany there are few programs that give breakfast to students. Similar breakfast skipping and feeding problems have been reported in Turkey (Türk, Gürsoy & Ergin, 2007).

Evidence suggests that breakfast consumption may improve cognitive function related to memory, test grades, and school attendance (Rampersaud, Pereira, Girard, Adams & Metzl, 2005). Breakfast as part of a healthful diet and lifestyle can positively impact children's health and well-being. Parents should be encouraged to provide breakfast for their children or explore the availability of a school breakfast program. (Rampersaud et al, 2005). Hunger during school may prevent children benefit from education. Therefore, many countries, both developing and developed, have invested large sums of money in school feeding programs to improve attendance, achievement levels, and nutritional status, and sometimes to provide extra income for poor families by reducing the amount of money they spend on food (Powell, Walker, Chang & Grantham-McGregor, 1998).

Some studies indicated that skipping a meal is more common among children of lower income families. And few studies investigated why students skip meals. Therefore, the study was conducted on students with low socioeconomic backgrounds and their feeding habits, meal skipping reasons was investigated. For this purpose the following problems are investigated.

- Do students skip a meal?
- For what reasons students skip a meal?
- Do skipping a meal and the reasons for skipping a meal change with respect to some demographic variables (monthly income of the family, gender, and parents' occupation)?

METHOD

In this research feeding habits of students who came from low socioeconomic families was investigated. Therefore, purposive sampling methodology was followed. Purposive sampling methodology allows researcher to investigate information rich cases (Patton, 1990). Furthermore, in data collection survey method was used.

Sample

The sample of the study consists of 162 elementary school students. The age ranged from 12 to 15. Of the 162 students 78 were female and 84 were male. Monthly income of the families ranged from 250 to 750€. Most of the parents of the sample were primary school graduates (115 of the mothers and 116 of the fathers).

Data collection procedure

Informed written consent was obtained from the students' parents after permission had been obtained from the governorship. Parents were informed about the survey and explained that the responses would be confidential. Moreover, they had an opportunity to review the questionnaire. The researchers explained the study to all the students. Students completed the questionnaire anonymously.

Data collection instrument

A questionnaire was developed by researchers in order to obtain information regarding students' feeding habits. The first part of the questionnaire was composed of demographic questions and the second part was composed of questions that are written to examine students feeding habits. The questionnaire was composed of 21 questions. The questionnaire was investigated by three independent researchers for a validity study. These researchers indicated that the required information can be obtained by the prepared questions. Moreover, it was administered to a small group of students (N=12) before the study in order to observe whether there is any incoherent points.

RESULTS

Results of the study indicated that in total 21.6% of the students usually skip a meal (14.2% breakfast, 6.2% lunch, 1.2% dinner). Furthermore, 28.4 % of the students indicated that they occasionally skip breakfast, 43.8% skip lunch and 14.2% skip dinner. Students indicated several reasons for skipping a meal. The most common reasons they have indicated were "loss of appetite (56.2%)", "lack of time (9.2%)", "inadequate pocket money (8.0%)", " to lose weight (5.5%)", "nobody prepares a meal (2.5%)" and "unnecessary (2.5%)". The proportion of students who usually had their breakfast, lunch and dinner out was 17.3%, 27.2% and 1.9% respectively. Students generally eat fast food and pastry (bagel, pastry with meat or cheese filling, biscuits) and rarely do they eat dish of meat, and vegetable dishes while having their lunch. On the other hand situation is reversed for dinner. One sample chi-square test was conducted whether skipping a meal changes with respect to gender. The results of the test were not significant (Table 1); the proportion of male and female students that skips a meal was not different. Chi square test indicated that meal skipping depends on mothers' occupation. The follow up test indicated that meal skipping child proportion is higher for self employed mothers. The other follow up tests were not significant. Furthermore, meal skipping proportion was found to be related with father's occupation. The proportion of children who skip a meal was higher in families in which father is unemployed compared the others and the proportion was statistically higher than all others. The other follow up tests were not significant.

Table1. Demographic patterns of meal skipping

	Percent	(n)	Total	Chi-square
Meal skippers	21.6	35	162	
Gender				
Male	21.4	18	84	NS
Female	21.8	17	78	
Income				
250€ and lover	24.1	20	83	
251-375€	14.3	6	42	NS
376-500€	20.8	5	24	
501-750€	30.8	4	13	
Mother				
Home duties/not	22.5	29	129	
employed	16.6	5	30	P < .05
Laborer	33.3	1	3	
Self employment				
Father				
Laborer	20.2	19	94	
Self employment	17.5	7	40	P < .05
Government officer			1	
Retired	14.3	1	7	
Unemployed	40.0	8	20	

DISCUSSION

Meal skipping affects students' health, cognitive performance and physical and mental development (Rampersaud et al., 2005; Powell et al., 1998). Meal skipping is not only the problem of underdeveloped countries; it is also a problem for developing and developed countries (Powell et al., 1998). Especially breakfast skipping which is an important factor on cognitive functions, is common among students (Murata, 2000; Dwyer et al, 2001). In this study a considerable proportion (21.6%) of students was found to skip a meal usually and especially breakfast (14.2%). Furthermore, majority of students indicated that they occasionally skip a meal. The reasons given for skipping meal were almost exclusively loss of appetite, lack of time, inadequate pocket money and to lose weight. Results indicated that meal skipping and especially the breakfast skipping is an important problem for this sample (low socioeconomic level). Moreover, another problem is that the students generally consume fast food and pastry when they eat outside. These problems may result from several factors including inadequate sleep/sleep quality, socioeconomic problems, education level of the parents and their occupations. Meal skipping affects students in variety of ways therefore families and students should be informed about the effects of meal skipping and fast food consumption.

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This chapter is one of the five communications of the Symposium "Education for sustainable development: international surveys on conceptions and postures of teachers" coordinated by Pierre Clément & Silvia Caravita

TEACHERS' UNDERSTANDING OF SUSTAINABLE DEVELOPMENT - DISCIPLINE BOUND DIFFERENCES

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Abstract: The purpose of this study was to investigate upper secondary school teachers' understanding of sustainable development (SD) and if their understanding differs depending on which subjects they teach. It is emphasized in the Swedish curriculum that SD is intended as a context for learning across the school curriculum and not only to be dealt with in certain subjects, and all teachers should teach according to a holistic perspective of SD. A holistic perspective integrates economic, ecological and social aspects. Since little is known about subject bound differences in teachers' understanding of SD we performed a nationwide questionnaire study among upper secondary school teachers (N= 3229), from 223 schools in Sweden. Pearson Chi-square test and Principal Component analysis was used to analyze the data. The result shows that differences in the way the concept is understood are linked to the subject taught. E.g. natural science and social science teachers think to a lesser extent that economic growth is important for SD compared to language, vocational and esthetical –practical teachers. There is also a difference of opinion regarding the social perspective and its inclusion in the concept. The ecological perspective is the perspective singled out by most teachers as integral to the concept. The results show incoherence in the way teachers understand SD, and it is not unlikely that they teach accordingly. The study points to the need for teacher education to provide a holistic understanding of SD including all perspectives. It is also important that in-service teachers are given further training.

Keywords: Sustainable development, Environmental education, Upper secondary school, Teachers understanding, Discipline bound differences.

THEORETICAL BACKGROUND AND RATIONALE

In 2005 United Nations launched a decade of education for sustainable development (SD), which address the impotence of education that empower people to develop attitudes, skills and knowledge to make informed decisions about, social, economic and ecological problems (UNESCO 2005). The Swedish curriculum states that SD should be integrated in all school subjects, and a holistic view of SD is intended to be the context for learning across the school curriculum, rather than only being addressed as an aspect of particular subjects (Swedish

National Agency for Education 2010). To fulfill these demands it requires that teachers, regardless of subject have appropriate knowledge and understanding of the complexity of the concept of SD. SD is a complex concept and several studies have shown that teachers have difficulties to understand the meaning of the concept. (e.g. Jucker 2002, Summers and Child 2007, Spiropulou et. al. 2007). Many teachers lack the necessary holistic perspective, which incorporate social, economic and environmental aspects (Spiropulou et. al. 2007, Summers & Child. 2007). A holistic view is seen as a necessity because social and economic factors often are the cause of environmental problems. To preserve the environment development is needed to meet humans' social and economic needs. Thus learning about economic, ecologic and social perspectives are intertwined and a prerequisite for each other in a holistic perspective of education for SD. Teachers lack of understanding could lead to difficulties when teaching according to a holistic perspective of education for SD because limited understanding of the subject often is related to limiting approaches to teach (Processer and Trigwell 1997). A holistic conception on the other hand has shown to lead to a broader approach to teaching and learning (Prosser and Trigwell 1997).

Many studies of teachers understanding of SD focus on geography or science student teachers' conceptions (e.g. Summers, Corney, and Childs 2004; Summers and Child 2007; Winter and Firth 2007) probably because these teachers traditionally taught environmental science and are looked upon as the predecessors expected also to teach SD. Little information exists on how education for SD is understood by teachers representing all subject areas, therefore further research is requested in other subjects (Corney and Reid 2007). This study presents the results from a nationwide survey in Sweden contributing to the comprehension of subject bound differences of upper secondary schools teachers understanding of SD.

PURPOSE AND RESEARCH QUESTION

The purpose of this study is to investigate teachers' understanding of SD and if this differs depending on which subject they teach.

Are there subject bound differences in upper secondary school teachers understanding of sustainable development?

METHODS

A stratified sampling of upper secondary schools (N=297) was conducted by the Central Bureau of statistics in Sweden (SCB), considering the size of the schools (three groups) and regions (four groups), to make sure that the sample was distributed on both small and large schools as well as different municipalities. Stratification by region provided a good geographic spread. 224 out of 297 schools (75 %) participated in our study and 3229 upper secondary teachers answered an online questionnaire with mostly liker-scale questions and some multiple choice questions. The questionnaire was first tested in a pilot study with 138 upper secondary teachers. Based on the pilot study minor modifications were made before the questionnaire was used in the main study. A large spread of teachers from different subject areas answered the questionnaire (over 20 disciplines were represented). 669 of the teachers were science teachers, 373 social science teachers, 483 language teachers, 713 vocational and esthetical-practical teachers, and teachers from remaining disciplines were 739. After the online questionnaire was closed the quantitative data was downloaded in SPSS version 18 for further data analysis. Persons Chi-square test was used to analyze relationships between variables, the significance accepted was $p<0.05$. Principal component analysis was used to analyze the relationship between how teachers responded in some questions.

RESULTS

Many (72%) teachers rate their personal understanding of SD as very good or good, but there was a difference between disciplines. Social science and science teachers rate their personal understanding of SD higher than the other subjects. 42% of the science teachers and 32% of the social science teachers report they have a very good understanding, compared to language teachers' (21%) and esthetical-practical/vocational study teachers (17%).

Subject bound differences in teachers understanding of SD was found in all tree perspectives (ecologic, economic and social) using PCA-analysis. The economic perspective of SD is the perspective of the greatest uncertainty, especially regarding the degree to which stable economic growth is a prerequisite for SD. Science and social science teachers look differently at the importance of economic development for SD compared to language and vocational and esthetical–practical teachers, see Figure 1. 10% of the science teachers and 14 % of the social science teachers agree that stable economic growth is a prerequisite for SD compared to 23 % of the language teachers and 25 % of the vocational and esthetical-practical teachers.

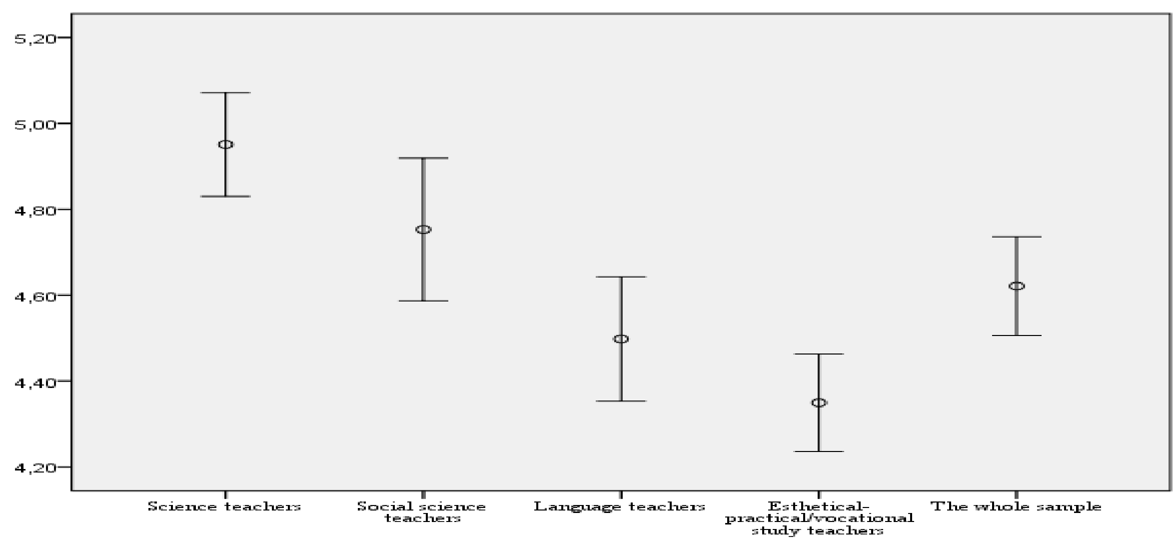

Figure 1. Indicator value (mean and 95% confidence interval) of the different teacher groups from the PCA-analysis about statements recognizing the economic perspective. The lower the number the more the teachers agreed the economic statements to be a prerequisite for sustainable development.

Our results showed that only about half of the teachers questioned considered social perspectives to be a component of SD. The social perspective was totally excluded from the understanding of sustainable development by 19 % of teachers and 29% only partially acknowledged its relevance. Results from PCA-analysis showed that language teachers, esthetical-practical and vocational study teachers in a higher degree recognizes the social perspective in the term SD than science and social science teachers.

The environmental perspective is the most recognized perspective of SD by all the teachers. Statements in the questionnaire that reflected the ecological environmental perspective received the strongest levels of agreement: *recycling waste products* (80 % completely agree), *developing new technologies to reduce the impact of harmful by-products of production* (72% completely agree) and *maintaining biodiversity in the local environment* (66% completely agree). However there were subject bound differences found using PCA- analysis, social science teachers recognize the environmental perspective in SD to a lower extent than language teachers and esthetical-practical and vocational study teachers did, see Figure 2.

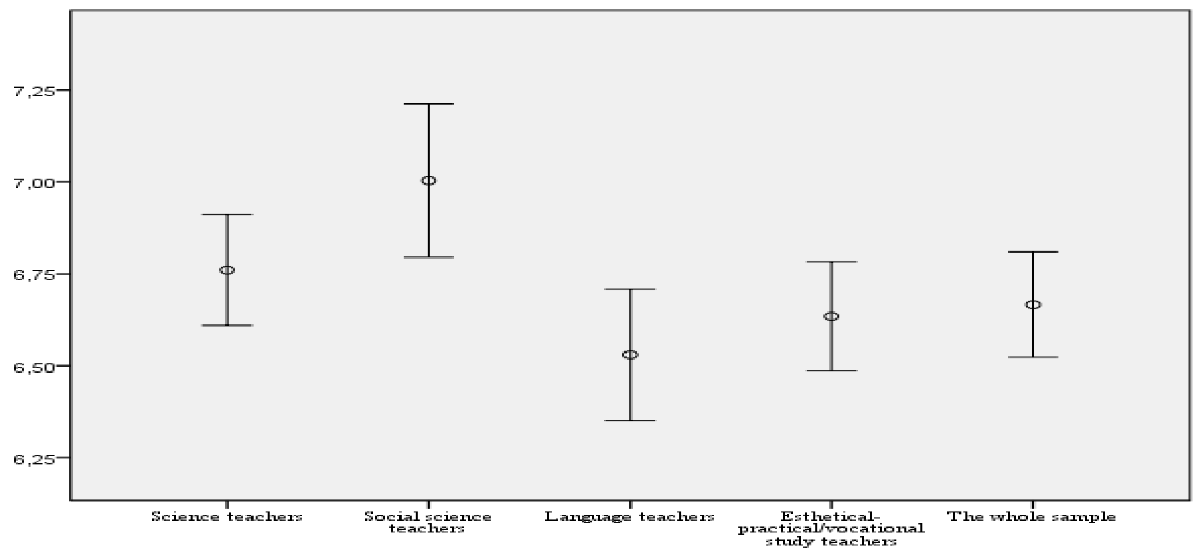

Figure 2. Indicator value (mean and 95% confidence interval) of the different teacher groups from the PCA-analysis relating to statements recognizing the ecological perspective. The lower the number the more the teachers agreed the ecological statements to be a prerequisite for SD.

Moreover we found that 76 % of the teachers had not studied SD as part of their teachers' education program and a majority (70%) reported that they had not received any further training of SD while working as teachers. A majority of the teachers want further training in SD (69%) but there were differences depending on discipline.

CONCLUSIONS AND IMPLICATIONS

This study shows that there is subject bound differences in teachers understanding of SD and it is not unlikely that they teach accordingly because limited understanding of the subject is often related to limiting approaches to teach (Processer and Trigwell 1997). The differences can be due to the fact that a majority of the teachers had not studied SD as part of their teachers' education program and had not received further training as in-service teachers. Therefore the teachers might build their conceptual understanding of SD on their own different subject traditions. This can be seen in the result of science and social science teachers, which emphasize ecological and social perspectives, respectively. Moreover social science and science teachers' had studied SD as part of their teachers' education programme to a higher extent compared to language teachers' and esthetical-practical/vocational study teachers. Surprisingly the civic teachers rated their understanding of SD as poorer than other teachers. The ecological aspect of SD is widely embraced by all the teachers in this study, which is in accordance with previous findings (e.g. Summers and Child 2007, Pepper and Wildy 2008). However the social science teachers recognized this perspective to a lower extent. The teachers' view of the economic perspective of SD is the perspective of the greatest variation among the different teachers, especially regarding the degree to which stable economic growth is a prerequisite for SD. This is also a highly debated issue in society depending on the interpretation of the concept of SD. However according to UNESCO (2005) stable economic growth should be integrated into a holistic view of SD. Science teachers and social science teachers seems more critical to this assumption, a result that could be interpreted as an imprint from the subject contexts of those teachers.

The influence of different subject traditions on individual's understanding of SD seems to be a general phenomena occurring at several different levels in the educational system. SD issues are marginal or even non-existent in some disciplines, but have a higher profile in others (Dawe, Jucker and Martin 2005). Most academic disciplines are limited by a set of disciplinary practices that constrain interdisciplinary efforts. Therefore, teachers are likely to build their understanding of SD on the foundation of their own subject traditions, as shown by the results presented herein. This could lead to problems in schools, in which sustainable development should be taught from a holistic perspective. In such a perspective interdisciplinary teaching is important for developing an understanding that nature and society constitute a holistic cluster of interdependent relationships according to Winter and Firth (2007). For teachers to work according to the Swedish curricula and the UNESCO guidelines this study points to the need for teacher education to provide a holistic understanding of SD including all perspectives. It is also important that in-service teachers are given further training about SD**.**

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TEACHING ABOUT PLASTICS AND EDUCATION FOR SUSTAINABLE DEVELOPMENT IN CHEMISTRY EDUCATION

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Abstract: This paper discusses the development and evaluation of a lesson plan for chemistry teaching, which combines the overarching theme "plastics" with issues of sustainable development. It was designed for upper and lower secondary school chemistry classes in Germany, and employs the socio-critical and problem-oriented approach to chemistry and science teaching. Using the example of conventional and alternative polymer materials, pupils are taught basic content matter in the field of polymer materials, including the properties and structures of several important examples of plastics. However, this lesson plan also focuses on two directly related societal issues: the environmental pollution problem caused by plastic waste and the important question of achieving the sustainable production of goods for keeping prosperity. Therefore, a special teaching method was implemented, which mimics the work of consumer testing agencies. This method combines learning about how consumer test agencies actually carry out their work with reflective exercises, which look at the various dimensions of evaluating technical and societal developments from a sustainability perspective. These dimensions include economic, ecological and social impacts. The paper gives an overview of the lesson plan's theoretical background and its structure. Results from the accompanying research embedded in a project of Participatory Action Research, which is based on teachers' reflections and open and Likert-questionnaires from the students, will be presented. The results reveal that this approach provides a motivating and challenging framework for learning chemistry, including the aspects of sustainability and the often complex interplay between science, technology and society.

Keywords: chemistry education, curriculum development, plastics, Education for Sustainable Development, Participatory Action Research

BACKGROUND, FRAMEWORK AND PURPOSE

Taking the societal dimension of science more thoroughly into consideration in science classes has been an often repeated demand for modern science education (Hofstein, Eilks & Bybee, 2010). One of the most challenging societal issues faced by modern societies is the question of how to reap the benefits of science and technology, while nevertheless protecting the environment and responsibly stewarding potential resources for the benefit of future generations. The juggling act of balancing current prosperity with the well-being of future generations has been subsumed under the banner of sustainable development and should of necessity be taken up by science education. After the Brundtland-Report was released, national policy-makers acknowledged that education has a key role to play in sustainable development. Education has a responsibility to turn out future citizens who are able to act in responsibly in society and, therefore, promote the concept of sustainable development (UNCED, 1992). Because of this, the UN declared the years 2005-2014 to be the Decade of Education for Sustainable Development (DESD), a period which was intended to integrate the principles, values, and practices of sustainable development into every aspect of education (UNESCO, 2007).

Within the overarching DESD structure, Education for Sustainable Development (ESD) has been operationalized in various ways, since every nation has its own plan of action. In Germany, for example, De Haan (2006) suggested a set of competencies which pupils should acquire in order to shape our society in a sustainable fashion. According to De Haan, such competencies encompass capabilities including communication, evaluation, and personal action in society. The didactic approach selected in this instance is in line with Bybee's (1997) concept of multidimensional scientific literacy as the major goal of any sort of science education. This also neatly ties in with Activity Theory-based science education and the German concept of *Allgemeinbildung*, or "general education" (Hofstein, Eilks & Bybee, 2010). Many other models show similarities with the German concept. They all focus on interdisciplinary learning, innovative methodology and the integration of societal, economic, and ecological aspects into science learning (e.g. Paden, 2000; McKeown, 2002, 2006)

Chemistry education faces a very special challenge within this framework (Burmeister, Rauch & Eilks, under review), because chemistry represents one of the core disciplines contributing to sustainable development in any industrialized society (Bradley, 2005). Innovative products and more efficient production methods lowering both waste and energy consumption would not be possible without modern chemistry research and development programs or without the widespread application of the principles of Green Chemistry in both research and production. Yet, even though chemistry plays a key role in sustainable development, the networking and dissemination of teaching materials focusing the learner's attention on sustainability issues beyond a purely technological perspective in chemistry classes typically remains a phenomenon of individual efforts in fits and starts. An organized, widespread team effort remains lacking in most countries and educational systems. In Germany, teaching practices that explicitly approach and expand upon ESD in chemistry education under recognition of economic, ecological and societal impacts remains the exception rather than the rule (Burmeister & Eilks, 2011a). Thus, our project aims at developing and researching new chemistry lesson plans and teaching materials in order to explicitly include ESD issues in German teaching. This paper presents a lesson plan on plastics, which combines the learning of basic chemistry with reflections on the implications this substance's use and production may have in the field of sustainable development.

METHOD

The research and development of this lesson plan was based on the Participatory Action Research (PAR) model for science education by Eilks and Ralle (2002). In PAR, teachers and researchers jointly develop and investigate teaching practices. PAR combines the evidence from educational research with the practical experience of in-service teachers as two complementary resources in their own right for the improvement of teaching practices. A group of teachers and researchers cooperatively design, test, research, and refine the lesson plans in a cyclical process. The output of this model includes new concepts and materials for teaching, an enlarged knowledge base of research on teaching and learning, improved practice, better trained teachers, and documentation of authentic teaching practices (Figure 1). The accompanying research collects evidence covering teachers' and students' perceptions of the lesson plan and its effects using a multi-perspective approach.

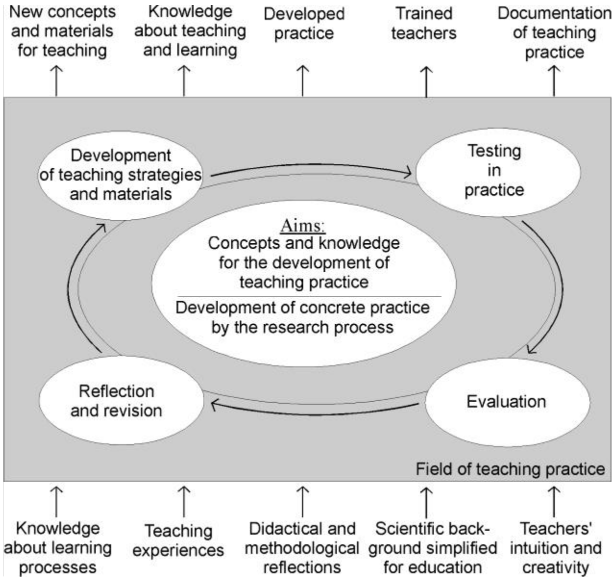

Figure 1. The model of Participatory Action Research in science education (Eilks & Ralle, 2002)

In our case, a team of 10 teachers from different schools (Markic & Eilks, 2011) worked on the design of a lesson plan for plastics, which included learning about the aspects of sustainable development. For roughly one year, the lesson plan was structured and repeatedly re-negotiated in monthly meetings of the action research group. Accompanying this process, several testing phases took place. After the changes had been adapted into the chemistry subject matter included in lesson plans, the lessons were tested in five different classes ranging from grade 9-13 (age range 15-19). Data was collected from both teacher reflections and discussions occurring during the regular meetings of the action research group. An open questionnaire covered students' reflections on: 1) what they considered to be the most important things they had learned, 2) their personal opinions about the lesson plan, and 3) what they now believed about the different types of plastics. Additionally, a Likert-questionnaire was filled out by the pupils, asking for their opinions of the lesson plan. Questions were subdivided into three parts, asking whether the students had liked the topic, how they would rate the methods employed, and if they had experienced a change in their personal attitudes towards the issues of sustainability, consumer tests and plastics.

LESSON PLAN

The lesson plan follows the 5-step model of the socio-critical, problem-oriented approach to chemistry teaching (Fig. 2) as described by Marks & Eilks (2009).

In phase 1, the lesson plan starts with a textual approach based on excerpts from authentic, controversial magazine reports covering the use of conventional plastics and comparing them with emerging environmental problems. The students are assigned different aspects taken from the texts, which are handled in the lesson plans. The material is structured in manner that provokes both questions about the basic chemistry of polymer materials and inquiries into their value with an eye towards the ecological, economical and societal perspectives.

Concept of the socio-critical and problem-oriented approach to chemistry teaching

Objectives	Criteria for selecting issues and approaches	Methods	Structure of the lesson plans
Allgemeinbildung/ education through science	Authenticity	Authentic media	1. Textual approach and problem analysis
(Multidimensional) Scientific Literacy	Relevance	Student oriented chemistry learning and lab-work	2. Clarifiying the chemistry background in a lab environment
Promotion of evaluation skills	Evaluation undetermined in a socio-scientific respect	Learner centred instruction and cooperative learning	3. Resuming the socio-scientific dimension
Promotion of communication skills	Allows for open discussion	Methods structuring controversial debating	4. Discussing and evaluating different points of view
Learning science	Deals with questions from chemistry and technology	Methods provoking the explication of individual opinions	5. Meta-reflection

Figure 2. Model of the socio-critical, problem-oriented approach to Chemistry teaching (Marks & Eilks, 2009)

In phase 2, students learn the basic chemistry content behind the various kinds of plastics with the help of a learning-at-stations lab exercise (Eilks, 2002). Each station covers different aspects of the production of plastics, the various properties and structures of polymers, differences between plastics and other materials such as wood or metal, and the nomenclature of important polymer materials.

Phase 3 resumes the societal debate and introduces students to a simple concept of sustainability. After reconsidering the initial question of how to evaluate different plastics (and their use) with respect to ecological, economic and social implications, phase 4 of the lesson plan, which is structured around the consumer test method (Burmeister & Eilks, 2011b), begins. The consumer test method as an application of the idea of mimicking authentic social practices (Eilks, Marks & Burmeister, 2011), in this case the practice product testing as performed by consumer testing agencies. In this phase, the learners compare different kinds of plastics: polyvinylchloride (PVC), polyethylene terephthalate (PET), and thermoplastic starches (TPS). Each of these plastics has individual advantages and disadvantages. The use of PVC is widely disputed in society, mainly because of certain plasticizers which are used in its production and the problem of an environmental friendly recycling and deposition. On the other side PVC is very stable, has fantastic properties and can be easily and quite cheaply produced. In contrast, PET is viewed in public debate quite neutrally. Nevertheless, there is debate because of serious environmental and social problems associated with the recycling process if PET waste is exported to countries with low social and environmental standards. TPS as a biodegradable polymer usually enjoys very positive populist reviews. But TPS is still expensive and has an extremely limited potential for widespread application. So all the plastics have advantages and disadvantages which in a holistic evaluation will counter interact.

M2 Evaluation Sheet

Plastics Evaluation criteria	My weighting factor	weighting factor of the group	Weighting factor of the class	my assessment	assessment of the expert group	assessment of the mixed group		
Plastic						PVC	TPS	PET
Green Chemistry	%	%	%					
Production and use without dangers for humans and environment								
No problems for disposal or recycling								
Production primarily from renewable resources								
Low energy costs for production								
Consumer and social interests	%	%	%					
Production, use and reuse take place according to West European social standards								
Safe usage for humans and animals also in the case of improper use (burning, swallowing, etc.)								
Products available cheaply everywhere								
Economy and industry	%	%	%					
Industrial production possible without subsidies								
Good marketability								
Recycling possible								
Material characteristics	%	%	%					
Good durability and long lifespan								
Good material properties and a broad area of usage								
Decision			100%					
Decision from the entire class								

Evaluation key:
++ = very good (1) + = good (2) o = satisfactory (3)
⊖ = barely sufficient (4) – = unsatisfactory (5)

Figure 3. Evaluation sheet for the consumer test method

Pupils work on the different kinds of plastic within a jigsaw puzzle classroom structure. They learn about the various advantages and disadvantages of each sort of material. A worksheet familiarizes the learners with the different perspectives such an evaluation can encompass. These range from the economic aspects of production to availability and consumer friendliness issues to ecological concerns about production processes and waste removal in the context of 'Green Chemistry'. It also asks them to weight the importance of the different dimensions. Stepwise following the Think-Pair-Share method the students have to negotiate a weighting between the different dimensions of a potential evaluation, namely properties, ecological, economic and social impacts. Then the students evaluate the pros and cons of their specific sort of plastic. The class is divided into small groups with at least three members each for this purpose. Each group covers one of the three types of plastics. The groups are asked to weigh these arguments against one other and evaluate the sort of plastic. Students work individually on their particular plastic first, assigning individual marks for each category, which will be discussed in their group later on. Beginning with their individual decisions, the students present and discuss their personal considerations and are forced to reach a compromise with their experts group. Following the jigsaw classroom method, the groups are mixed then together in such a manner that at least one expert for each type of plastic is in the new group. The newly-formed groups thoroughly discuss and evaluate all the type of plastic in comparison. The pupils' groups then jointly fill out an evaluation sheet (Fig.3). By the end of this process, each group now has completed the entire evaluation sheet and the final marks can be calculated, first within the individual groups of the second round of the jigsaw classroom, then for the entire class.

The processes of weighting and evaluating are reflected upon in the final phase. At the heart of the reflection stand the questions of how such evaluations occur and how they are influenced by the individual decisions of the people conducting the test and/or writing the reports. This reflection focuses on the role of scientific information and its constant transformation and filtering in the process of evaluation, but also touches upon the reliability of information sources and the transformative process, which occurs whenever members of consumer testing agencies use, relate and weight information in the sense of “filtered information” (Eilks et al., 2011). Another point which is discussed is the marks assigned to the products. Students are asked if they had initially expected the marks to turn out differently and why this was so. Another interesting discussion point is that individual marks generally differ from the end decision reached by the entire class. This makes clear the above-mentioned influence and importance of individual weighting and personal interests and contrasts them with consensus-based, group decision-making processes, where compromise on an issue is unavoidable (Eilks et al., 2011).

FINDINGS

Judging by the teachers’ reports, this lesson plan proved to be both highly feasible and motivating for their learners. The students were highly involved in both inquiry activities and cooperative learning processes right from the start. For example, the question of how to evaluate different sorts of consumer products was an unfamiliar and challenging one for most of the participants, students and teachers. Many pupils had some difficulty in the areas of assigning their own weighting factors and in reaching joint agreements. This phase incited intense discussions about the different sorts of plastics. More importantly, it provoked debate about the role the various evaluation dimensions should have in categorizing a product like plastics. For example, the durability and affordable prices associated with PVC ran headlong into this plastic’s poisonous nature if burned under uncontrolled conditions and its environmentally persistent nature if not handled through sustainable recycling. The excellent degradability of TPS was contrasted with its high production cost and limited applicability. Such contradictions led to productive confusion and intense reflection upon the evaluation process itself. In the end, it was also interesting to see that the different opinions in all the learning groups were flattened to an average value, with no extreme positions being represented by the final outcome. Each type of plastic was found to be neither very good, nor very bad. This was not what the pupils had expected to see, as they bluntly stated in the open questionnaire. Even some of the teachers mentioned that they had never really intensely reflected upon consumer testing activities in such an intense fashion.

Most pupils agreed on the questionnaire that they considered the lesson plan to be very useful for their future lives. About 65% totally (30% partially) agreed that they now felt able to cope with consumer test reports released to the public. Roughly 75% totally (20% partially) agreed that the lesson plan had made them think more thoroughly about the use plastics. Approximately 65% (20% partially) agreed that they had changed their opinion about plastics. Among the different learning groups, younger pupils tended to more fully agree to most of the statements on the questionnaire. Older students sometimes said that they had already been critical about the use of plastics. Nevertheless, even among the older students a majority agreed that the learners had become more critical towards consumer testing results and/or the use of plastics. Especially the older participants mentioned that learning about plastics and consumer tests was useful and relevant for their lives. With respect to ESD, over 80% of the pupils agreed that they now better understood what the discussion about sustainable development is really about. An overview of all the results is given below (Fig. 4).

Many students recognized in the open questionnaire that it is possible in chemistry education to learn more than just chemistry subject matter. They did consider the learning in chemistry within this lesson plan to be relevant for their lives. For example, students mentioned to have gained knowledge about sustainability and the way consumer tests are devised and carried out. Some explicitly mentioned that they had become more critical towards consumer tests and what they had to offer. Only a few pupils offered criticism of the teaching unit. A few replies to the questionnaire said that the lessons had not included enough chemical reactions and formulae, and that participants had had to discuss things too much. A feeling was expressed that this type of lesson is not really "chemistry", but would better fit into the social sciences. This observation reveals an interesting insight into the perception of chemistry held by these pupils. Discussing controversial issues and evaluating chemical content does not seem to belong to their definition of chemistry class (e.g. Marks & Eilks, 2010). In their opinion, such things are not considered to be a reasonable requirement of chemistry teaching and learning. It appears that the conventional teaching approaches experienced by these pupils up to this point have given the learners only an abbreviated, distorted picture of what chemistry really is. But these were only a few students. Overall, the questionnaire delivered very positive feedback, which is the case for the results from both the open questions and the Likert-test items.

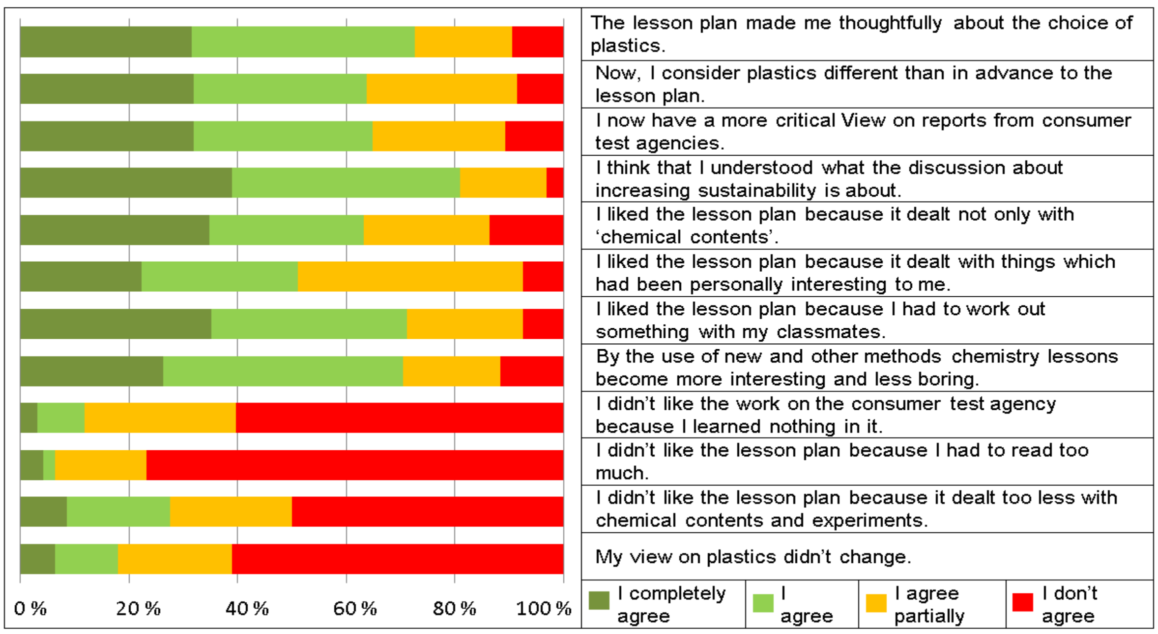

Figure 4: Results of the Likert-questionnaire

CONCLUSIONS

Using Participatory Action Research as a starting point, this project was able to cyclically refine the teaching materials developed, aided by feedback from the teachers and students alike. Although there were some initial problems caused by the complexity of the method, solid results could be reached during the evaluation. In the final analysis, this lesson plan on plastics and their broader implications for sustainable development proved to be a very highly motivating addition to the ESD-geared curriculum and pedagogy being developed for German chemistry lessons. This was especially successful thanks to the inclusion of the consumer test method (Burmeister & Eilks, 2011b), which added an authentic, societally-relevant and controversial facet to the learning process. This is supported by the responses of both the students and their teachers.

Like previous examples of such teaching units (e.g. Marks & Eilks, 2010) have demonstrated, the socio-critical and problem-oriented approach to chemistry teaching (Marks & Eilks, 2009) has shown itself to be a very feasible platform for undertaking such lesson planning. The case study presented here reveals that this approach can provide very fertile ground fruitful for integrating important aspects of ESD more thoroughly into everyday chemistry teaching, including the use of more explicit and multidimensional methodologies in this process, at least in the case of Germany. As the ensuing evaluations showed, students can become increasingly contemplative with respect to both their environment and the decisions they make concerning sustainability and available resources. This is an encouraging and very useful step when it comes to creating a modern, sustainable society of responsible stewards, who do not lose sight of future generations and the problems they may face.

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HOW STUDENT TEACHERS FORM THEIR EDUCATIONAL PRACTICE IN RELATION TO SUSTAINABLE DEVELOPMENT

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Abstract: This study investigates experienced student teachers' perceptions of their professional training to encompass education for sustainable development, ESD. Data were collected by using questionnaires. The findings indicate that teachers' implementation of ESD depends on both external and internal factors. Three major external factors have been found: colleagues, time and the curriculum. The internal factors were identified as transformative phases; especially a disorienting dilemma, self-examination, exploration of options for new actions, acquisition of knowledge and skills, and integration of new action in the teaching of ESD. Tensions between the individual teacher as a professional versus the teacher as a private person are explicitly mentioned as well as tensions with other teachers, principals and the community. These results may be important to teacher education as well as teachers' professional development as they provide insights for implementation of changes in the educational system.

Keywords: education for sustainable development, educational change, transformative learning, external factors, internal factors, student teachers, disorienting dilemma.

Education for change needs change in education

ESD has been described in the Swedish curriculum since 1994 as a "learning to illustrate how society functions and the way we live and work are best adapted to create sustainable development" (National Agency for Education, 1994). However, the degree to which teachers are prepared to work with these issues varies with the consequence that ESD cannot yet be considered satisfactory implemented in all schools (National Agency for Education, 2009).

Working with education in a changing social and policy context is demanding and the descriptions of education for sustainable development are still blurred. The widely accepted definition of ESD from the WCED (1987) "Sustainable development is to be able to meet the needs of the present without compromising the ability of future generations to meet their needs" is both vague and open to interpretations (Wals, 2006). Analysis of the concept "education for sustainable development" shows that it differs from environmental education and is more than a new name for the same content. Teachers thus need to change their teaching. This change is not only about new knowledge – but perhaps involves even changing the frames of reference for how to understand the world. That implies a teacher role and a teacher identity that might mean a transformation for the teacher. The theories of transformative learning offer an analytical tool for such research.

Transformative learning

Transformative learning is described as a process in which individuals alter the frames of reference in terms of understanding the world in order to make them more comprehensive and perceptive. Jack Mezirow (2000) describes ten stages of a transformative process:

(a) A disorienting dilemma; it shows when the learner describes some kind of tension or dissatisfaction with the situation, that could also be recognized as a trigger event for the transformation.

(b) Self-examination; becoming critically reflective of the premise of the problem

(c) A critical assessment of assumptions

(d) Recognition that your discontent and the process of transformation are shared with others; there is a connection between your discontent and the process of transformation

(e) Exploration of options for new roles and actions, relationships and action

(f) Planning a course of action

(g) Acquisition of knowledge and skills for implementing your plan

(h) Provisional trying of new roles

(i) Building of competence and self-confidence in new roles and relationships

(j) A reintegration into your life on the basis of conditions dictated by your new perspective

Critical self-reflection is thus necessary to bring about a change of frames of reference, a potential change of perspective. This approach to learning focuses particularly on values, ideals, and emotions, moral as well as abstract concepts such as liberty, justice, responsibility and democracy. Moore (2005) furthermore stresses that

> I believe sustainability education must be interdisciplinary, collaborative, experiential, and potentially transformative. Sustainability education is also a process of creating a space for inquiry, dialogue, reflection, and action about the concept and goals of sustainability.
>
> Moore, p. 78

Teacher identity research has found that professional identity has a major impact on the way teachers teach and their ability to cope with changes in the educational system (Nias, 1989).

Rationale and research questions

Teacher education is a powerful arena for educational change and the student teachers are potential change agents who soon will be heading out into school as teachers. Thus, these experienced student teachers near graduation are an interesting group to study. Three research questions guide the study:

1. What external factors are described by the student teachers as barriers in their teaching of ESD?

2. What internal factors – analyzed in terms of the phases in the transformative learning - can be identified in the student teachers reflections about their relation to education for sustainable development?
3. What tensions, dilemmas and conflicts are described by the student teachers?

The methodology and interpretation of the statements in this study is informed by a qualitative categorization (Cohen et al, 2007) where the qualitative data analysis involves making sense of patterns, themes, regularities and categories. The empirical design uses questionnaires. This collection of written data provides relatively short and reflected answers compared to oral interviews. All student teachers answered the following questions:

1. If you got unlimited resources, then how would you educate for sustainable development?

2. What barriers can you see in order to achieve your goals explained in the previous question?

The sample in this study consists of 20 student teachers, with diverse subjects in their degrees. The age range of the respondents in this study is from 24 to 55 years, with a total of 20 student teachers, 6 male and 14 female. Data were collected using questionnaires during a compulsory course in education for sustainable development and all of them answered the questions.

In this study two analytical tools are operationalized to fit the structure of the results. Firstly, Hargreaves (2004) distinction between external and internal factors is used in the analysis. These external and internal factors are used to analyse whether these student teachers refer to something external that affect their action, such as politicians, policy documents, pupils, community, colleagues, or if they describe more internal processes. Secondly the internal factors are compared to the transformative phases and interpreted in order to discern similarities or differences.

Results

The answers express how the student teachers discern certain external factors such as time, colleagues and the curriculum that impact their action. The student teachers also express knowledge about the writings in the curriculum regarding sustainability. The responses show descriptions of an educational system that is perceived to be slow in its process of change. It also appears that the student teachers are unsure of the exact nature of the requirements that the school has on the teachers related to ESD and what is expected beyond the more traditional environmental perspective “recycling and paperless classroom”. The content in ESD is described by the respondents as focusing on particular issues such as environment, consumption, health, democracy, energy, justice, resources and economy. The answers also describe the teaching methods as collaborative and interdisciplinary; ESD requires individual skills as well as a collective competence.

Internal factors-the different phases of transformative learning

The different perceptions held by the student teachers are described thematically and then compared to the transformational phases and some excerpts of the typical statements are represented in this table. The internal factors were interpreted as they correspond to the transformative phases although the sentences often are difficult to precisely put in just one of the transformative phases. None of the answers suggest that the current situation is satisfying. When one of the student teacher says ”… we are destroying our world ” it is in the same answer described that she talks about human rights, environment as well as working conditions, that everything is connected, social perspectives as well as the environment. The self-examination (phase *b*) is a reflective mode when individuals look at their own situation. The competence in the field of sustainability issues – or rather lack of competence – is emphasized in several statements, for instance as described in "… that my knowledge in the field isn´t large enough could also be a barrier". Sometimes personal shortcomings – such as laziness or shortage of time – are expressed in the answers, for instance "No, I don´t always practice what I preach, but I´m aware of it and try to do something about it. Because of comfort, laziness and tiredness I prioritize other things…" Many answers talk about that it is important what other people do, for instance "Sustainable development demands cooperation, work interdisciplinary, work in teams".

Overall, many alternative actions are described in the answers (phase *d*) in order to change teaching methods; to cooperate with the surrounding community, field trips, but also to welcome other professionals to school. No teacher student in this study is without suggestions for actions. Some of the answers show that it is work in progress "…sustainable development has a price, I try to live as lean as possible but I haven´t acted in every way yet".

The exploration of options for new roles (phase *e*) can apply to the teacher as an individual as well as a professional and these different roles are often intertwined in the answers. Some explorations are described not only for the individual's own action but for a collective action as well: "Send all teachers and principals together on professional development". The provisional trying (phase *f*) and the planning of a course of action (phase *g*) are sometimes difficult to discern from each other in the answers, on teaching practice the student teachers have opportunities to both plan and try out new actions, such as "we plan a project about consumption, all teachers will cooperate about this for three weeks".

The student teachers also address several of the economical, ecological and social dimensions of sustainability (phase *h*). The statements show that this group of student teachers describes interdisciplinary cooperation as important, tradition-breaking and unusual. Many of the student teachers describe that they want to work interdisciplinary and wish they would experience that in their professional training. The building of self-confidence in new roles (phase *i*) – which is an issue of identity, is described typically as "It's about working on issues that do not have simple answers, this requires a humble teacher's role, sustainable development also requires collaboration". Thus, openness to the surrounding world, engagement and non-prestige are characteristics that these student teachers express and are typical of the professional role related to education for sustainable development. Some of the student teachers describe the acquisition of a competence that involves a change in attitude towards the teacher's control of learning. The signs of reintegration in your life (phase *j*) are recognized in different ways such as the student teacher highlights a thumb rule for how to act, for instance "to set a good example and practice what you preach, above all, never do the opposite of your values“. Signs of courage – in not always having the correct answers – could be seen as expressed in “I do not always know the answer, but must have the courage to address things that are not entirely clear. Teachers have to be self-critical”. The teacher role in education for sustainable development is described as “the role of the teacher seems to be quite fuzzy, some teachers, at some schools, seem to have come a long way, others have barely begun to reflect on sustainable development”. The description of the integration of the new action is also depending on external factors such as colleagues, time, resources, leadership, policy documents and other incentives, which complicates the process of change for the teacher.

Described conflicts of interest in ESD

Conflicts between various interests are described in the answers when the student teacher interact with teachers, management, policy documents, time, pupils, financial resources and their own lifestyles. Overall, an image is emerging in this study of student teachers who want to cooperate with others, allowing themselves not to know the answers to everything, who do not use an explicit norm about how society ought to be. This teacher identity seems to have a strong personal commitment, often self-critical and work with existential issues. However, between the lines a different picture emerges: other teachers who do not cooperate, who guard their own subject, not engaged in content or students, not reflecting on their teaching role, not changing their educational practice. These two poles: the individual self and the other lead to friction in the interaction, a tension between the individual and the environment.

Three tensions could be identified; either between the student teacher as having a professional role versus a more private role as well as tensions with other people (described as teachers and principals) and the educational system. The student teachers put high demands on their own lifestyle, both as a professional with great insight into human needs and a strong character. Some of them express shame or guilt that they, as private persons, are unable to live by their ideals related to sustainability issues such as sustainable transport, sustainable consumption and sustainable energy. Other responses also describe how the teacher is expected to “teach how things fit together”. It is described as a high trustworthiness to act on your speech; this also seems to be perceived as something new and challenging in the teacher role. Significantly the student teachers describe it as central to collaborate with colleagues when working with ESD.

Discussion

The motivation to educate for sustainable development is strongly expressed for these respondents but they experience many barriers for the implementation of ESD, external as well as internal. The research question regarding the internal factors related to education for sustainable development has been compared to the different phases of transformative learning. According to the transformative learning theory the student teachers will undergo a process of change only if they are dissatisfied with the way they perceive the current situation. All these external and internal factors put the student teachers into dilemmas and conflicts when reflecting over their teacher identity. Their dealing with these conflicts, tensions, dilemmas, arguments and disagreements are described in the answers. This implies a teacher identity that is different from transmission of facts or norms. The difficulty to identify a common framework of understanding what education for sustainable development could mean contributes to the difficulty the student teachers say they perceive. Anxiety for not being good enough as a teacher can lead to many things; both dropouts from the profession, illness or even turning towards a cynical approach to the profession. These possible consequences need to be addressed, as noted by Hargreaves (2004). If we can understand the change process that these experienced student teachers undergo, it could lead to better teacher education and professional development for teachers.

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DEVELOPMENT OF COMPETENCES AND CONDITIONS FOR GOOD PRACTICES IN ESD. A QUALITATIVE INTERNATIONAL SURVEY

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Abstract: The concept of competence is still controversial. An operational definition in the educational field considers competence « *holistic in the sense that it integrates and relates external demands, individual attributes (including ethics and values) and context as essential elements of competent performance".* Each competence emerges from the interaction among « *knowledge (including tacit knowledge), motivation, capacities, attitudes, values, emotions, mobilized for effective actions in particular contexts ».*

Our qualitative analysis identified competencies expected by projects of Education for Sustainable Development and the conditions for their development. Reports about "good practices" of UNESCO associated schools and an inventory of case studies in Italian Secondary Schools have been analysed to highlight the five learning pillars (to know, to do, to be, to live together and to transform) pursued by these experiences. The specific competencies were matched with a list of ESD themes, and with phases of realization of projects aimed at producing some change in the close life-environment.

The development of the teachers' competencies seems to largely occur in parallel with the actualization of the experiences; teachers' and students' motivation appear mutually contagious and certainly play an important role.

The integration of disciplinary knowledge in real life problems, and the identification of unifying trans-disciplinary conceptual networks, need attention.

Keywords: Education for Sustainable Development – Competencies – School practices

THEORETICAL BACKGROUND

The concept of competence is still controversial and even more so, its application in the real curriculum is far from being consistent with its potential innovative drive, as highlighted by the opinions and experiences expressed by the participants from 46 countries in the E-Forum on Approaches by Competencies (2006).

Conceptual and procedural knowledge were viewed as separate and independent cognitive competences in the solution of problems before being inter-related in a model of development in which either one or the other may develop first and influence the other depending on the experiences offered by the context to the learners (Sophian, 1997). "Conceptual knowledge may guide their attention to relevant features of the problem and help them to organize their information in their representation of the problems. This well-chosen problem representation may then support generation and use of effective procedures” (Rittle-Johnson and Siegler, 2001)

The initial tendency in cognitive sciences was to discriminate among ways of defining competencies which focused on cognition or performance or on knowledge domain (specific or general). The DeSeCo project achieved a consensus on an operational definition of competence in the educational field: « *holistic in the sense that it integrates and relates external demands, individual attributes (including ethics and values) and context as essential elements of competent performance”.* Each competence emerges from the interaction among cognitive and practical abilities : « *knowledge (including tacit knowledge), motivation, capacities, attitudes, values, emotions, mobilized for effective actions in particular contexts* ». In addition to cognitive competencies, competence-related motivation plays a very important role.

The *competent handling of a situation* constitutes the principal criterion for evaluating situated competence (Jonnaert et al., 2006). Therefore, in a competency-based curriculum, exit profiles specify the classes of situations that learners must be able to handle competently by the end of their education.

RESEARCH QUESTIONS

The design of ESD strategies promoted by UNESCO is based on the integration among three dimensions: environmental, social and economical situated in cultural contexts, and on a constructivist perspective about teaching/learning that aims at developing learning to know, to do, to be, to live together, to transform

The relevance of this interaction among knowledge, values and attitudes and practices is widely acknowledged by the educational systems as the fertile humus for the growth of competencies, but countries have specific priorities concerning the expected competencies. Many of the competencies envisaged for ESD correspond to the key-competences for education: act autonomously, use physical and socio-cultural tools (symbolic languages among them) for effectively interacting with life-environment, with others in heterogeneous groups, for participating as active citizen. But other competencies are strictly linked with the objectives and pedagogical approach of ESD that makes multi-disciplinarity, systemic and critical thinking the core of its actions.

Our research wants to explore which kinds of students’ and teachers’ competencies are potentially developed by the ESD projects in the actual school practice. To which extent are they specific of cultural contexts? Which are the features of the projects and the conditions in which they are enacted that teachers assumed to be effective for the growth of competencies? Can they be assessed? Which recommendations might be generalized for the diffusion of ESD ad also the transfer of its strategies to other areas of curricular teaching?

METHODS

Our study is a bottom up investigation carried out through a qualitative analysis of reports about ESD projects. We have concentrated on Secondary School projects and given priority to the variety of themes treated. Our sources of information are:

- UNESCO selections of “good ESD practices” that collect the reports written by the teachers following a predefined grid. The projects belong to five regional areas

(Africa, Arabian area, Asia and Pacific area, Europe and North America, Latin American and Caribbean area)

- Inventories of case studies in the Italian Secondary Education collected by direct contacts with the coordinators of the projects.

The reports for each school project have been analysed by filling up a table as the one inserted below (most of the work was done in French).

Competencies (KVP, inside a cultural context) K = Scientific Knowledge, V = Values, P = Practices					
Theme and location. Declared objectives Disciplines involved Promoters of the project Collaborating agencies	**« To know » (connaissances, démarches, valeurs)**	**« To be » (valeurs, attitudes, motivations)**	**« To do » (pratiques, savoir-faire, valeurs)**	**« To live together » (valeurs, pratiques, connaissances)**	**« To change » (soi-même, les autres, l'environnement)**

Twenty projects have been presently analysed. Ten Italian ESD experiences have been identified and the teachers who coordinate these projects have been interviewed to highlight their conceptions of competencies and of the positive and negative factors influencing the ESD activities in schools. The analysis of these interviews is still in progress.

Our formulation of the competencies that the students have possibly built has to be considered as an a-posteriori emergent construct, because it synthesizes the information contained in the table and the description of the pedagogical approach of the project.

The competencies have been clustered by ESD themes to highlght the aspects that were privileged; they have also been organized within a framework that links the competencies to different modalities of students' participation in the projects.

PRELIMINARY RESULTS

The examined projects document the great creativity and dynamism of the engaged teachers and schools. The development of the teachers' competencies seems to largely occur in parallel with the actualization of this kind of experiences because teachers' and students' motivation appear mutually contagious and certainly play an important role.

Actions aimed at introducing changes in the local environment, in making the school a point of reference and a resource for the community, make the goals of most of the experiences. The challenges faced by these goals, individually and collectively accepted, are at the origin of the high motivation: there are no pre-existing answers to the questions, everyone is intellectually and operatively engaged.

It is interesting to underline that the reports of the projects rarely use the term of competence to specify either what is envisaged either which were the results attained by the learning processes. We considered the competencies as the eventual integration of the five kinds of learning that were more or less explicitly indicated in the reports.

We reproduce here an example from our report for the UNESCO (Clément and Caravita, 2011, p. 65):

Table N°11, Accademia de Averroes Peace Programme, Pakistan

Context: Communities where students experience the consequences of cultural and religious prejudices

Knowledge: knowledge about cultures and religions of the social groups composing the community; awareness of the interconnections among discrimination, economic deprivation and social marginalization; understanding the interdependence between environmental and human health

Cognitive abilities: ability to give meaning to cultural diversities, ability to search for relationships among socio-economic, cultural and environmental dimensions in contexts, critical thinking; ability to de-contextualize and generalize problems

Practical abilities: abilities for establishing positive social relationships with different members of the community, skills for cooperating in actions of social solidarity, communication skills

Attitudes: curiosity, openness, trust

Emotions: empathy, appreciation, satisfaction, self-esteem, self-confidence

Values and ethics: responsibility, valuing diversity, pursuing the ideal of justice

Motivations: willingness to share with others, interest in diversities, motivation to go beyond the surface of facts, availability to be involved in concrete social actions and policies

Competencies: competence to make explicit the prejudices that undermine the cohesion of local society (racism, integralism, injustice, …); higher awareness of the factors which require a responsible engagement at the individual and social level to contribute to build a more sustainable future; capacity to communicate, to understand and to cooperate with other members of the community with open-mindedness and appreciation for diversity; better understanding of the interdependence between ways of living and environmental quality.

We found clear evidence that the competencies are cued by and coherent with the context itself, its demands, the situations/problems which are identified or which are created by the pedagogical approach. Therefore to formulate the competencies in general terms seems to erase the many important variations that distinguish the school class experiences among them when engaged in similar projects (without mentioning the individual differences). Listing standard ESD competences might result in a sterile exercise, even if it appears necessary for orienting the design and assessment of projects.

The activities planned by the teachers are finalised to "problems for sustainability and search for solutions " but the projects may involve the students in different phases of this process, therefore the contribution of the types of learning in building the competencies may differ. The students can mainly have the role of *participants* in "models" of action, or of *designers* of possible solutions, or of *actors* in the operational translation of projects. We therefore framed the competencies in categories (Clément and Caravita, 2011) that may help to reflect on how knowledge, abilities and values can be implicated in different ways.

One critical point in teachers' mediation, in fact, seems to be how to regulate the interaction among these components consistently with the purposes of the ESD project, how to capitalize on motivation and emotions as magnifiers of cognition. The integration of disciplinary knowledge in real life problems, the identification of unifying trans-disciplinary networks are issues which demand for greater attention in teachers' education and in the curricula.

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DIVERSITY OF TEACHERS' CONCEPTIONS RELATED TO ENVIRONMENT AND HUMAN RIGHTS. A SURVEY IN 24 COUNTRIES

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Abstract: The environmental, social and economical dimensions of ESD include human rights as equality of all the human beings independently to their gender, ethnic group, religion or sexual orientation. To analyse teachers' conceptions on environment and on human rights, and to identify eventual links between them and with controlled parameters, a large survey has been done in 24 countries (8 749 teachers). The data are submitted to multivariate analyses.

In the less developed countries, the teachers' conceptions are more anthropocentric, less awareness of the problem of the limit of resources in our planet, and less reticent to use GMO (genetically modified organisms). These teachers are more believing in God, more practising religion, more for *"a strong central power", "against the separation between science and religion"*. The priority of ESD in these countries is poverty and development, while it is to avoid wasting and excessive consumption in the most developed countries.

The teachers with the most anthropocentric conceptions more agree with these propositions: *"It is for biological reasons that women more often than men take care of housekeeping*" and "*Ethnic groups are genetically different and that is why some are superior to others*", and more disagree with: "*Homosexual couples should have the same rights as heterosexual couples"*. These points illustrate that some socio-cultural traditions can differ from values of ESD (the universal human rights).

Keywords: Environment – Teachers - Values – Gender – Human Rights –

THEORETICAL BACKGROUND

Most of the countries include now ESD (Education for a Sustainable Development) in their national curricula, even if some of them still call it EE (Environmental Education, e.g. in Brazil or in Colombia, where EE already included social, economical and political dimensions), or EES (Environmental Education for Sustainability, e.g. in Australia) avoiding the word "*Development"* more understood as "*Growth*" than as a possible "*Metamorphosis*" of our societies. The topics of ESD are far to be limited to ecology or environmental problems; they also include the social and economical dimensions of SD (Sustainable Development, Brundtland report 1987), including human rights.

ESD is focused on learners' competences. « *The conceptualization adopted in DeSeCo (OECD 2002) is holistic in the sense that it integrated and related external demands, individual attributes (including ethics and values) and context as essential elements of competent performance"* (Rychen, 2004, page 21). In each competence, *"knowledge (including tacit knowledge), motivation, capacities, attitudes, values, emotions,* (are) *mobilized for effective actions in particular contexts* » (Rychen, 2004, page 22).

The values underlying ESD were categorized in diverse works (synthesis in Caravita *et al.* 2008). Several of these values are also underlying Education for All, Education to Citizenship and Human Rights : e.g. for the equality of all the human beings independently to their gender, ethnic group, religion or sexual orientation (UNESCO, 2009, page 9). Other values, more focused on Environment and Sustainability, are specific to ESD.

ESD is facing a paradoxical injunction, taking into account the local socio-cultural specificities, but also universal values (mainly scientific and citizenship values). To face this question, we did an international survey implying different socio-cultural contexts. Our research is trying to identify eventual interactions between scientific knowledge and values in teachers' conceptions (as suggested by the KVP model: Clément 2006, analysing conceptions as possible interactions between scientific knowledge, K, values, V and social practices, P), and the present communication is focused on the analysis of eventual correlations between values related to environment and those related to some human rights.

RESEARCH QUESTION

What are the teachers' conceptions, and mainly their values implied in competencies for ESD, in a variety of different countries? More precisely, is there some correlation between their values related to environment (as ecocentric or anthropocentric ethics) and their values related to some human rights as equality among all the human beings, independently to their gender, ethnic group, sexual orientation, or religion?

METHODS

The teachers' conceptions were analysed from their anonymous answers to a large questionnaire elaborated by the Biohead-Citizen project (Biology, Health and Environmental Education for better Citizenship, 2004-2008), elaborated and validated collectively during two years, using previous interviews, pilot test, etc (Clément & Carvalho 2007). 27 questions are related to nature, environment and environmental education, other questions are dealing with the eventual biological justification of differences related to the gender, to ethnic groups or to sexual orientation; other questions concern personal information, including political and religious opinions. We present here only some results of the survey.

In each country, the sampling was well balanced: 1/3 primary schools teachers; 1/3 secondary schools teachers of biology; and 1/3 secondary schools teachers of language. In each sample, there were half of in-service teachers, and half of pre-service teachers (end of their training). The countries were chosen from their diversity: 18 for the Biohead-Citizen project (13 in all Europe, 4 in Arabic countries and 1 in sub-Saharan Africa). More recently, were added 2 other European countries (Denmark and Serbia), 2 countries of sub-Saharan Africa (Burkina-Faso and Cameroun), Brazil and Australia. The number of the interviewed teachers in each of the 24 countries is indicated below on the figures 1 and 2 (total = 8 749).

The distribution of answers inside each of the 24 countries can be illustrated by histograms as below in figures 1 and 2. The data were analysed with different multivariate analyses (presented in other works as in Munoz *et al.*, 2009). A between analysis was used to identify the answers which discriminate the most the countries, and a test of randomisation (Monte Carlo type) shows that the difference among the countries is very significant ($p < 0.0001$). A Co-Inertia analysis correlates the PCA from the questions related to environment with the PCA from questions related to the teachers' socio-political and religious opinions. Another Co-Inertia Analysis correlates the environmental variables with those related to some human rights (equality men – women, among ethnic groups, etc.).

MAIN RESULTS AND DISCUSSION

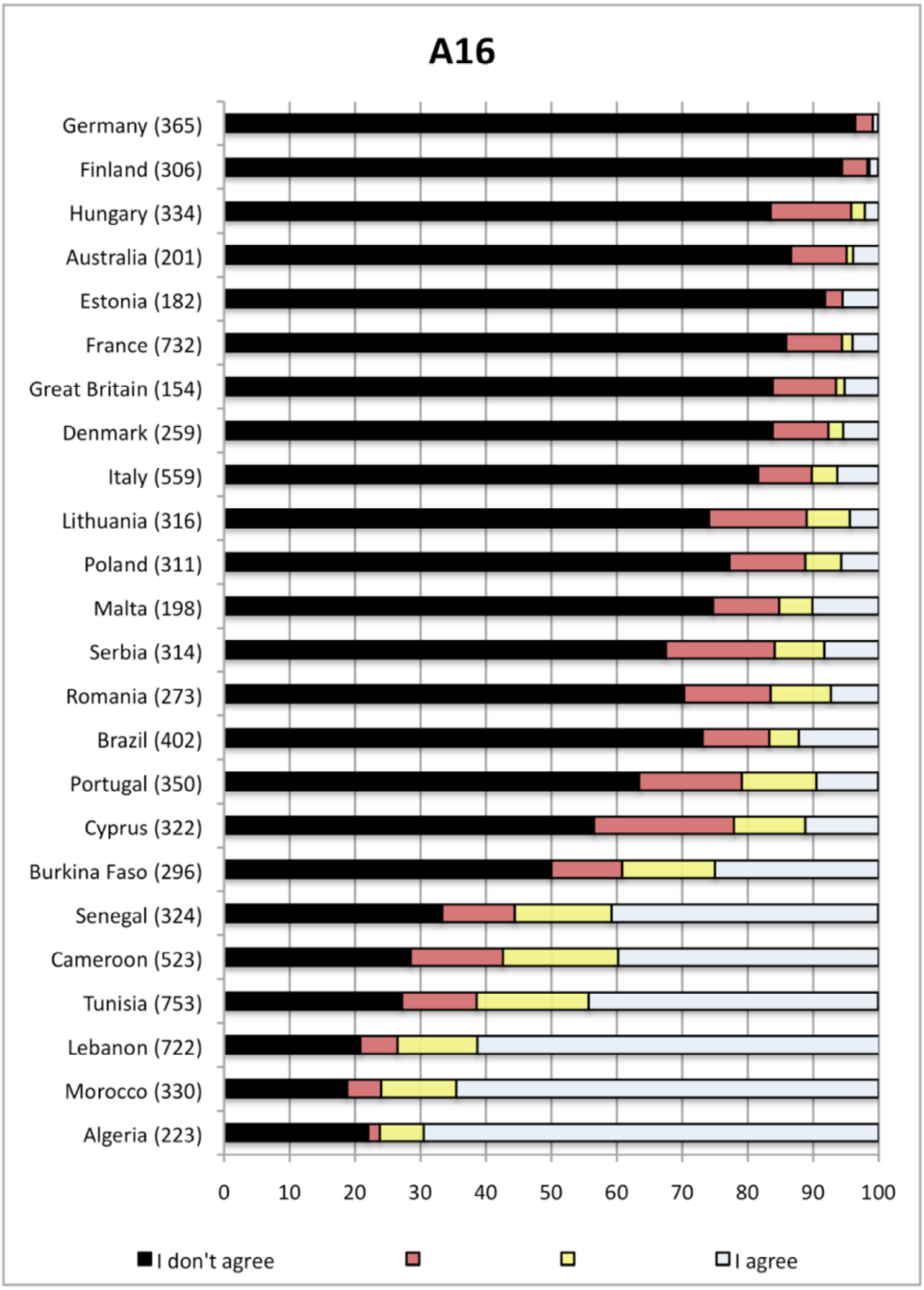

Figure 1 – Answers of the 8 749 teachers (grouped by country) to the questions **A16 - *"Our planet has unlimited natural resources"***

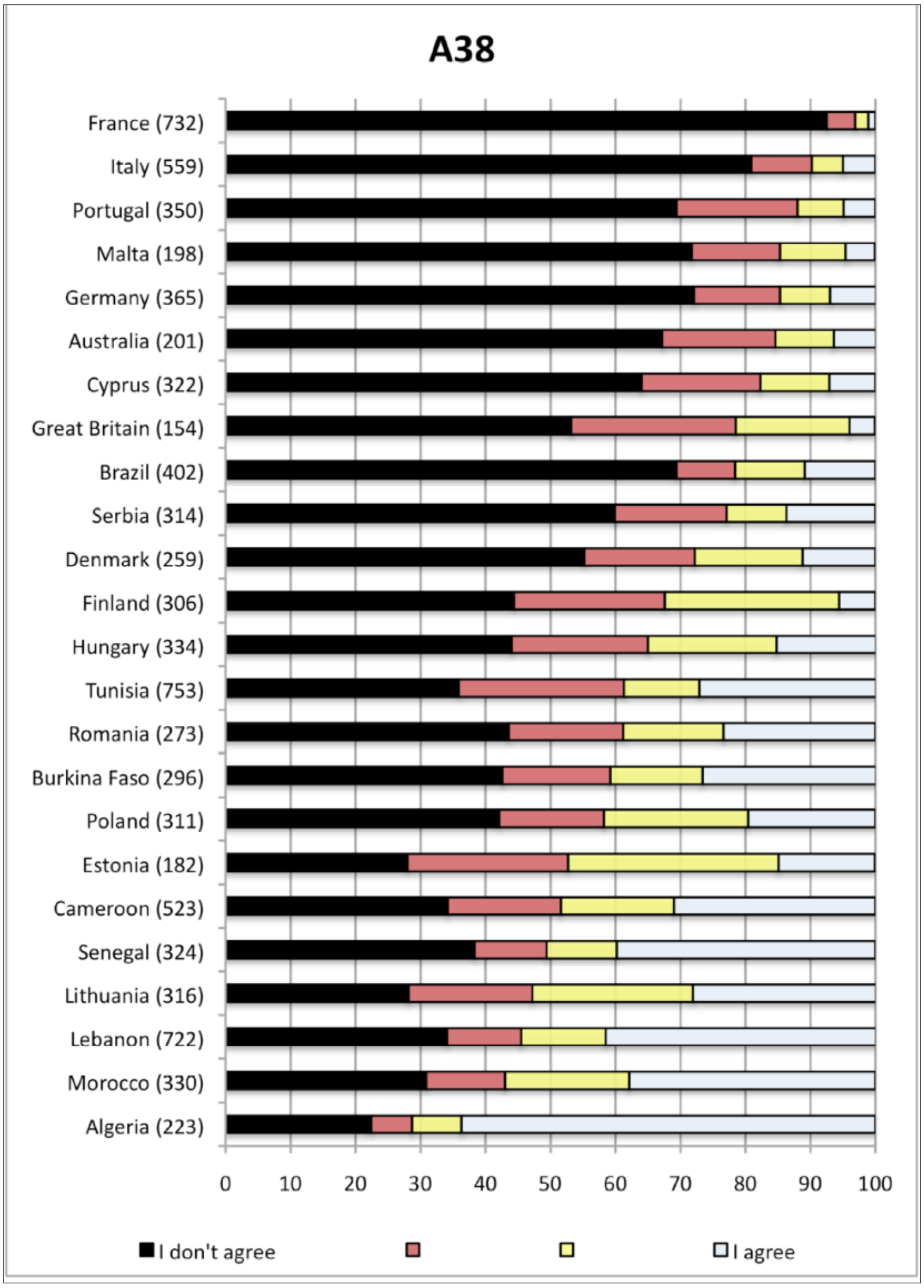

Figure 2 – Answers of the 8 749 teachers (grouped by country) to the question **A38 –** ***"It is for biological reasons that women more often than men take care of housekeeping"***

The 24 countries very significantly differ from several questions related to teachers' conceptions on utilisation of the environment (Several questions concerning teachers'conceptions on utilization of the environment make the difference mong the 24 countries:): as questions A16 (figure 1: *"Our planet has unlimited natural resources"),* A17 *("Society will continue to solve even the biggest environmental problems"),* A18 *("Human beings are more important than other living beings")*, A39 *("Genetically modified plants are good for the environment because their cultivation will reduce the use of chemical pesticides (e.g. insecticides, herbicides)").*

Globally, teachers of the less developed countries have more anthropocentric conceptions, being less awareness than their colleagues from other countries of the problem of the limit of resources in our planet, and less reticent to use GMO (genetically modified organisms). These conceptions probably can be related with the importance of poverty in these countries, and the urgent necessity of a better economical development. The implementation of ESD in these countries has to take into account this specificity, not using the same situations as in developed countries where inverse problems are a priority (to avoid wasting and excessive consumption).

The first Co-Inertia Analysis shows a significant correlation between the same environmental variables (anthropocentric values) and some religious and socio-political parameters. The teachers having the most anthropocentric conceptions are the most believing in God and practicing religion, independently to the religion (e.g. in figure 1, A16 : most of the teachers in Cameroon are Christian, while >90% of them are Muslim in Senegal). Politically, these teachers are more for *“a strong central power”, “against the separation between science and religion”,* and for *“laws to help firms”.* All these parameters are probably linked to the low level of development correlated with stronger religious practices.

The second Co-Inertia Analysis shows another set of correlations. The teachers with the most anthropocentric conceptions more agree, for instance, with the propositions A38 (figure 2: *“It is for biological reasons that women more often than men take care of housekeeping*”) and A35 (“*Ethnic groups are genetically different and that is why some are superior to others*”), and more disagree with A41 (“*Homosexual couples should have the same rights as heterosexual couples”*). The biological justification of superiority of men or of some ethnic groups is today considered as ideological and not scientific; as an interaction KV (knowledge and values) justifying some still actual social practices (P). Why is it so present in teachers’ conceptions in Arabic countries, but also in sub-Saharan Africa, and in countries of North and East Europe? These points, as other comments of the figures 1 and 2, and of all our results, will be presented and discussed in a larger publication. They illustrate that some socio-cultural traditions can differ from some values of ESD (the universal human rights).

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THE TURKISH ADAPTATION OF THE ENVIRONMENTAL EDUCATION AND ECOLOGICAL BEHAVIOR QUESTIONNAIRE

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Abstract: The purpose of this study was to create an instrument to measure environmental attitude and ecological behavior of pre-service science teachers in order to investigate the predictive power of environmental attitude and knowledge in relation to ecological behavior. Hence, this research includes adaptation of an environmental attitude and ecological behavior questionnaire (EAEBQ) into Turkish and reports validity and reliability of the study. Adapted instrument developed by Kaiser, Wölfing and Fuhler, (1999) is a likert type instrument with five scales and includes 26 items. The sample was 108 university students from two universities in Turkey. The data collected from two universities was analyzed and the Cronbach's alpha reliability was found to be 0.710. Environmental education and ecological behavior are the core of the most commonly used attitude approaches toward the environment and all these concepts forms the conceptual skeleton of the planned behavior. Then, this study draws attention to the role of the education and the faculty of education to improve our understanding of the ecological behavior.

Keywords: Science education, environmental education, environmental attitude adaptation, pre-service teacher education.

Background, Framework, and Purpose

Environmental issues are increasingly taking more attention of the entire world for last decades. Especially after the 1970s environmental problems have been accounted as their social dimensions as well as technical and economical dimensions. With the awareness of environmental issues' social and economic dimensions and modified knowledge about environment, our perspective in terms of gained environmental knowledge, attitudes and behavior have been changed (Digby, 2010). Starting with assumptions that the environment is in danger and must be saved, some environmental problems and solutions are propounded.

From this perspective The UN Conference on the Human Environment in Stockholm, Sweden in 1972 is important as it was the first conference about environment and environmental problems (UNEP, 1972). Then, the Belgrade Charter conference of educators at Belgrade, Yugoslavia, in 1975 developed a framework of understandings for the field. The other important intergovernmental conference was Tbilisi Declaration in Russia, in 1977. In this conference declared goals, objectives, criteria and principles for the field (www.nzaee.org.nz). The World Commission on Environment and Development in 1987 entitled as "Our common Future"(Brundtland, 1987) is the other most important report that emphasize the importance solutions for environmental problems in terms of social and economic dimensions. These conference and reports make this clear that environmental problems are social problems, caused by the behavior of people and it is crucial that how to “educate” people to become "part of the solution" by taking action to save sustainability.

Environmental education (EE) is developing new behaviors not only at the individual level, but also at society. EE emphasizes development of scientific knowledge and appropriate solutions for environmental problems. Moreover, environmental educators and researchers have long been interested in knowledge about and attitudes toward environment since it was assumed that knowledge and attitudes significantly influence environmental behaviors (Coyle, 2005; Kollmuss & Agyeman, 2002; Koupal & Krasny, 2003; Smith, Rechenberg, Cruey, Magness & Sandman, 1997; as cited in Kaiser, Wölfing, Fuhler, 1999).

Environmental attitude is also considered one of the most promising concepts (Newhouse, 1990). Almost % 70 of all environmental psychological publications cover environmental attitude (Kaiser, Wölfing & Fuhler, 1999). Many studies indicate that if people have high level of environmental concern they should be more likely to engage ecological behavior (Roberts, 1991; as cited in Roberts & Bacon, 1997). Also, so many researchers thought that poor attitude-behavior correspondence is a result of inappropriate attitudinal specificity (Roberts & Bacon, 1997). Hines, Hungerford, and Tomera (1987) concluded that there was a positive moderate relationship between environmental attitudes and behavior (Hines, Hungerford & Tomera, 1987). Roberts and Bacon (1997) also stated that who have highly environmental concern, choose products that create less pollution and try to make ecologically correct decisions about products.

Based on the related literature stated above research questions of this study were determined as follows:

1. Is Environmental Attitude and Ecological Behavior Questionnaire (EAEBQ) reliable to use into Turkish culture to assess pre-service science teachers’ environmental attitude and ecological behavior?

Rationale

Although there are some studies about environmental attitude, some of which are conducted with adults, consumers and different levels of students. There are limited studies about pre-service secondary education science teachers’ environmental attitude, knowledge and behavior in Turkey. Also, most of studies in the literature do not use environmental attitude as a predictor of ecological behavior, still as researches indicated that there is a gap in research done in the area of relationship between environmental attitude and behavior in university students (Kaiser, Wölfing, Fuhler, 1999). Also the original environmental questionnaire includes all these three aspects. For this reason, this study have importance to fulfill this gap especially for Turkey by considering the predictive power of environmental attitude and knowledge in relation to ecological behavior at pre-service science teachers, and to measure the relationship between ecological behavior and environmental attitude of pre-service teachers from different departments.

Moreover, requirement of environmental education in universities is the most prominent issue in nowadays (Moody et. Al., 2005; CELP, 2005; Kaplovitz & Levine, 2005). Because, after graduation from university, one is expected to reflect his learned environmental value, attitude and behaviors his surroundings. Therefore, the goal of the universities should be facilitate to have knowledge and positive attitudes about environmental issues and develop new behaviors towards the environment. So, determine of university student’s environmental attitudes and then measure the relationship between attitude and behavior are the crucial in the environmental education. This study have importance to fulfill this gap especially for Turkey by considering the predictive power of environmental attitude in relation to ecological behavior at pre-service science teachers, and to measure the relationship between ecological behavior and environmental attitude of pre-service teachers from different departments.

Methods

The original Environmental Education and Ecological Behavior Questionnaire (EAEBQ) consists of 28 items on a 5-point Likert-type scale. The response categories were “absolutely disagree”, “disagree”, “undecided”, “agree”, and “absolutely agree”. The subscales of questionnaire are Environment Knowledge (EK) and Environmental Values (EV) and Ecological Behavior Intention (EBI).

In this study, EAEBQ was adapted by researchers by the way of one-way translation. First, the EAEBQ was translated from English to Turkish by two of researchers. Addition to researchers, one more independent bilingual researcher translated the original questionnaire into Turkish, allowing divergent interpretation of items with ambiguous meaning in the original questionnaire. The Turkish form of the EAEBQ was checked over by one environmental education expert in terms of appropriateness of the items in order to check the face and content validity. According to the feedbacks, some items were found to be inappropriate for Turkish culture and items 14 and item 16 were dropped out from the study. Finally, EAEBQ revised and final form of the questionnaire was produced. The adapted instrument is a Likert-type instrument with five scales, includes 26 items and it was applied to 108 pre-service science teachers (48 physics teachers, and 60 chemistry teachers).

Results

The data were collected from pre-service science teachers and analyzed via PASW for Windows. Pre-service science teachers’ responses were tallied according to their response (for example; absolutely disagree =1 or absolutely agree =5). Negatively formulated items were reversed in coding. The maximum score is 130 and the minimum score is 26. The reliability of the EAEBQ was analyzed as Cronbach’s alpha value and found as .710 for the total test. For educational studies, the suggested alpha value is at least .70 and preferably higher (Fraenkel & Wallen, 2003, pp.168). Also reliability analysis of subscales of the test were done. Cronbach’s alpha value of EK subscale was found as .764, Cronbach’s alpha EV subscale was found as .610 and Cronbach’s alpha value of EBI scale is .492.

Conclusions and Implications

In the questionnaire, each subscale’s Cronbach’s alpha reliability was found as .764, .610, .492 respectively. Although, the last two subscales’ reliability value was not met the recommended criteria, Cronbach’s alpha value of the full EAEBQ (α=0.710) was acceptable. In the light of these results, it can be said that the adaptation of this questionnaire successful and appropriate to use EAEBQ in the Turkish culture to determine pre-service science teachers’ Environment Knowledge (EK), Environmental Values (EV) and Ecological Behavior Intention (EBI) by taking into account satisfactory reliability and validity results .

After validity and reliability analysis of EQEBQ is appropriate to use for pre-service teachers at various grades. Predictive power of environmental attitude and knowledge in relation to ecological behavior at pre-service science teachers, and to measure the relationship between ecological behavior and environmental attitude of pre-service teachers from different departments can be examined with EQEBQ. Effects of gender on environmental knowledge, attitude and behavior should be examined as well as predictive behavior.

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CONTRIBUTION TO THE DESIGN-BASED FEATURES ENHANCING ILL-STRUCTURED PROBLEM SOLVING: CAMPFIRE PROBLEMS

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Abstract: A design-based research was conducted in order to enhance the solution of the ill-structured campfire problem taken as cases from participants' direct experiences in nature. The solution of the campfire problem was a cyclic process which had some variations and refinement from phase 1 to phase 3. The cycles were examined in accordance with design-based research characteristics. The findings concerning the enhancement of ill-structured problem solving in the framework of design-based research were chosen. This study aims at contributing to use of ill-structured real-life problem solving including outdoors within the framework of design-based research as a pioneer study.

Keywords: Design-based research, Outdoor physics education, Ill-structured problem solving Case-based instruction.

INTRODUCTION

Design is a common method used for solving real life problems. It is a complex process, encompassing many skills and activities. Students need support to execute the various activities involved in designing successfully, such as analyzing the situation to understand the problems and issues that need to be addressed, gathering information, generating alternative solutions, generating criteria to evaluate solutions, thinking about trade-offs, and justifying choices (Puntambekar and Kolodner, 2005). Instead of a contrived curriculum presented through an artificial context, design tasks are supported by learning on demand, where learning goals emerge from the situation at hand. In other words, because design problems are ill-structured, professors cannot determine a standard curriculum until students actively devise methods for addressing the design problem (Nelson, 2003).

Most studies including real life problems take the experience students bring to class as basis. However Campbell, Lubben and Dlamini (2000) used science based everyday problems and found the percentage of responses demonstrating the use of science low particularly for students who have been taught through a context based approach, and thus they suggested that bringing 'everyday situations' into 'school science' does not readily enable students to bring 'school science' into 'everyday situations'. Similarly Fortus (2005) suggests providing students with an experience in which they apply their knowledge in real world contexts and Krupa (2002) states that the potential for educational opportunities in an outdoor classroom is limitless. Moreover an important resource for physics education still seems relatively unexplored: physics activities in `nature' (Popov, 2003) where children make meaning from their direct experiences (O'Brien and Murray, 2007). Gürel et al. (2007) argue that although it is obvious how important the outside school experience is for their profession, very few teachers attempt to make use of it, however the 'applied knowledge' they need to establish in their science classes is a connection between science and daily life.

On the other hand particularly due to the social facet of it, this study is based upon Vygotsky's Social Constructivism Theory. According to this theory knowledge is social in nature and is constructed through a process of collaboration, interaction and communication among learners in social settings (Vygotsky, 1978).

METHODS

Using design-based research methods, qualitative data were collected through field notes, open ended questions, individual and group reports and the video transcriptions of the lessons including in-class and outdoor discussions about the campfire problem within the framework of the data gathered from prospective physics teachers about the driving question during the three-year implementation period, from 2007 to 2009, as three major phases. All these phases were conducted within Area Elective 2 Course in which case-based instruction was used.

The learning environment was an integration of class with outdoor settings. The term outdoor was used as a large context including nature through one or two days residential camps, field trips and activities in campus-site as complementary experiences of residential camps. The learning environment had been arranged as a result of permanent partnerships with civil defence directorate and volunteers, participation of researchers in training programs regarding outdoor education, their collaboration with experts when needed and researchers' experience increasing year after year.

Researchers were included in the process as facilitators. Related to the campfire problem, this study focuses on the following research question: Which characteristics of design based research are evident in this study? The participants were prospective physics teachers, civil defence volunteers and experts as collaborators.

In this study contextualization was basically provided through experience and observation of the real phenomenon in its natural environment. The content of the course mainly depended on residential camp experience which was new and extraordinary for almost all students.

The real-life situations which are studied in the broader research including this study are the components of residential camp life. The broader research focuses on incorporating indoor and outdoor settings and it has covered the years from 2007 to 2009 as an incomplete PhD dissertation.

RESULTS

Many researchers used design-based or so called design research and expressed its characteristics (Collins, Joseph and Bielaczyc, 2004; Fortus et. al., 2004; Brown, 1992; Nelson, 2003; Joseph, 2004). This study evaluated more prominent ones of these characteristics which were considered to be the factors that caused variations of the campfire problem. The variety and refinement of the design as one of these characteristics is left out of this study to be described in detail in a further study.

Within this study, the implementations of the campfire problem belonging to three phases were handled as three cycles. All the cycles commenced with the same driving question and in a certain stage they were supported by residential camp experience. The cycles are given in figures 1, 2 and 3 respectively.

Each cycle was different from one another depending upon the characteristics of participating people and environment (Gürel and Doğan, 2010b), and the increasing experience of researchers. However each cycle had the characteristics of design-based research.

Basically relying upon the following characteristics of design-based research, the research question of the study was answered.

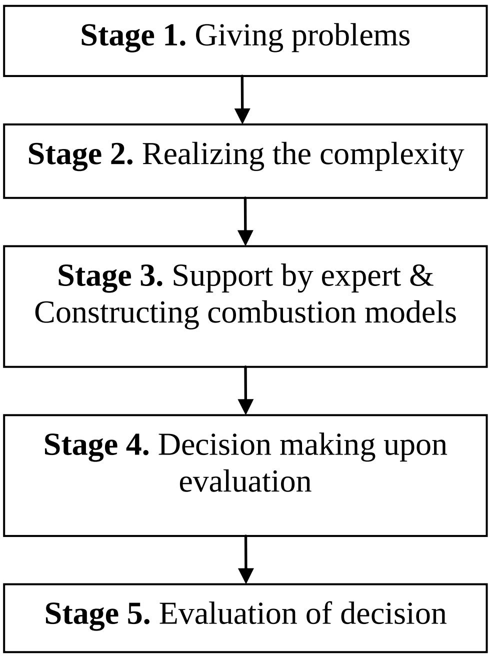

Figure 1. Cycle 1

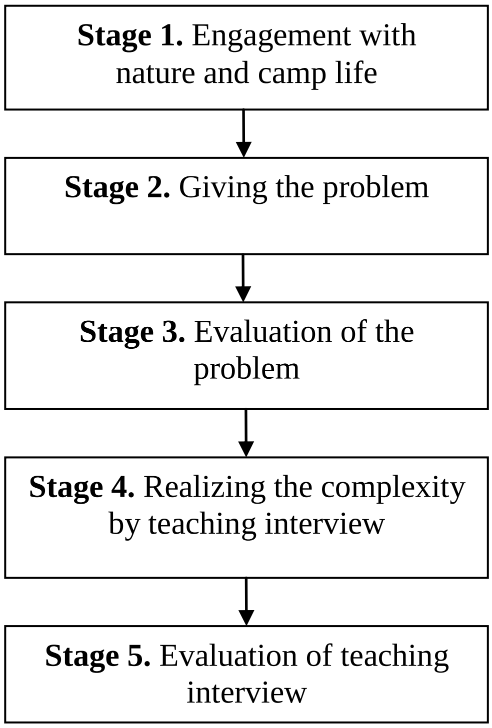

Figure 2. Cycle 2

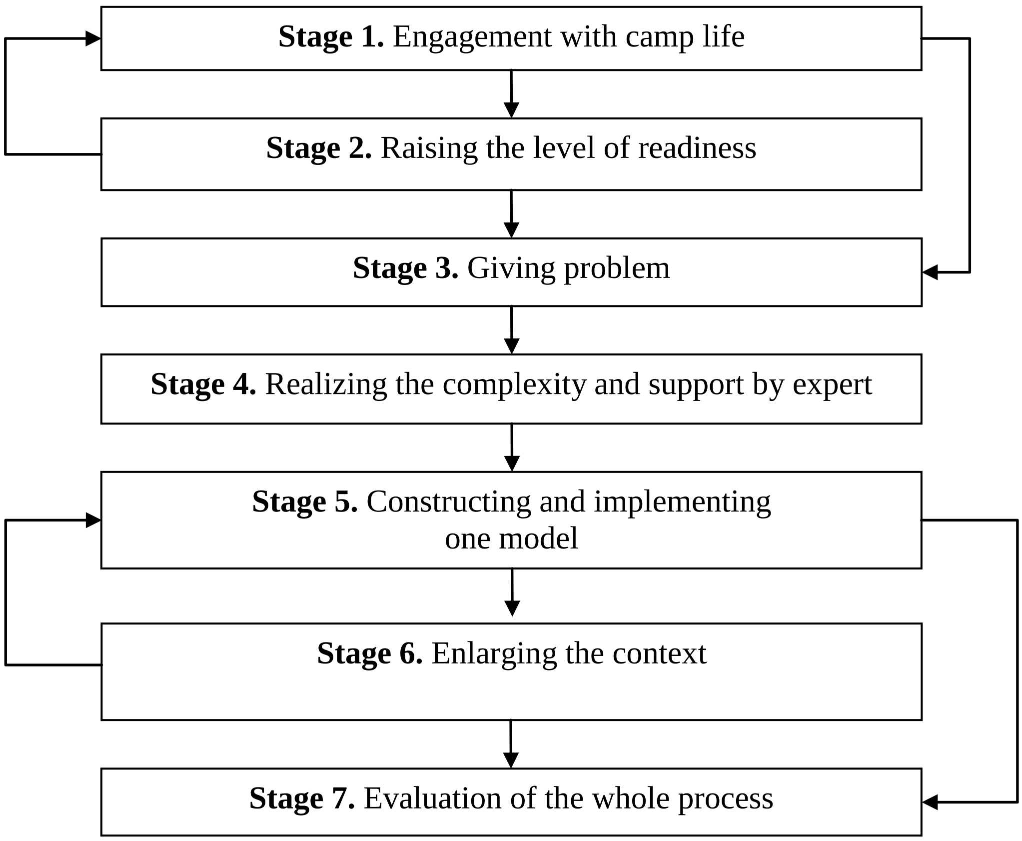

Figure 3. Cycle 3

a) There are many variables that cannot be controlled

The weather

Because it rained heavily during one of the camps in phase 2, there was an exaggeration in the description of wilderness and its adventurous aspect in students' narratives and this resulted in the formation of relevant ill-structured problem.

Unexpected events

There was a void of distractions which were present in city life including mobile phones most of the time, not because they were not allowed but because they had generally no signal. Nevertheless it was not a totally isolated learning environment because of bystanders who also affected the study. One of the most extreme examples was the death of a young man from another group, falling down a rocky hill around the campsite. Two students in our group who were also civil defence volunteers intervened in the accident and almost all members of the group also took part in the search but not rescue step of the activity.

There was a genuine collaboration between a civil defence volunteer and the instructor of the course for the organization of outdoor activities but he died unexpectedly in phase 1. It was not possible to find a civil defence volunteer who had such comprehensive knowledge of camping and who was also so highly motivated to participate in camps organized within the course. This also affected the design so that the camp, meaning that the observation and experience of the campfire, was delayed until the end of the semester in phase 1.

Complexity of the problems

There were many human and environmental factors that could not be controlled. Gürel and Doğan (2010b) revealed such factors that affect the results of the implementations for three years in a comparative analysis. The campfire problem was multivariable and even good students needed the cyclic process of design-based research to solve such a problem. When prospective physics teachers faced the problem on the incidence, they grasped the complexity and used verbal statements showing that they could not handle with it. Some of their utterances gathered in the practice of making a model campfire and discovering the variables in the campus-site in phase 1 were as follows:

Student 1: There are many variables in this setting.

Student 2: How can we control so many variables?

Henceforth, it was seen that students were unified as a group in their opinions on their emotional responses including complaint and despair.

b) Large amounts of data

The researchers were to handle with a plethora of data gathered in the broader research including this study through three cycles. However in this study we focused on the campfire, not its relation to other factors such as awareness or safety, and not the conceptions of prospective physics teachers about combustion, but the solution process of the ill-structured campfire problem. So there was a reducement in data to analyse the solution process.

c) Consultation with subject matter experts outside the classroom

Collins, Joseph and Bielaczyc (2004) insisted on the importance of the consultation with experts and stated that this gave the students access to real expertise from outside the classroom and acted to validate the importance of their research to the students. Choi and Lee (2009) aimed at developing a case-based instructional model and while implementing their model they exposed students to experts' different ideas for solutions and then asked them to refine their initial ideas for solutions.

In this study while conducting cycle 1, there became a need for deeper knowledge of an expert in the field of combustion. Then, an academic focusing on combustion in his research studies was included in the process through an interactive lecture given by him (Gürel and Doğan, 2010a). Expert knowledge was transferred to other cycles through researchers. Because having the solution of a similar problem was considered to facilitate the solution process, expert knowledge was also integrated with Faraday's lectures on candles in cycle 3. Thus burning candle problem was involved in the process as it was a similar and simpler one for the campfire problem in this cycle (Doğan and Gürel, 2010). The knowledge of building a campfire necessitated outdoor expertise and this expertise was included in all cycles.

d) Introducing the driving question

The driving question of this study was "How do you build and maintain a campfire throughout the camp?" and it was the same for all cycles. However the way of providing prospective physics teachers' engagement in the driving question varied through phases. In cycle 1 the context was set with the presentation of photographs from the camps of the previous year and the presentation of the driving question. In cycle 2, a group of students commenced to conduct research on providing outdoor resources for the needs of logistics and campfire. And they accomplished the practice through cooperation with the expertise of civil defence. In cycle 3, prospective physics teachers were exposed to the experience of building a campfire directly beforehand in a preparatory camp having a very flexible program before the initiation of group work. Moreover taking the responsibility which was a requirement of camp life disseminated to the whole settings of the course. The most prominent factors which were effective on the campfire varied through camps as well and this affected prospective physics teachers' engagement in the problem. In cycle 1, which was dependent on the implementations of the previous year through related photographs, the most prominent factor was the size of the log which had to be burned for a continuous campfire. While it was the heavy rain in cycle 2, it was the colour of the flame in cycle 3.

e) Being grounded in real-world settings

The real-life situations which were studied in the broader research including this study were the components of residential camp life. They were personally experienced and observed at camps by students, recorded by photographs and videos taken.

CONCLUSION

The need for support of an expert was evident in all cycles. It was revealed that support of experts was required in compliance with the nature of design-based research in the whole process whether it was subject matter or civil defence knowledge. During phase 1 the researchers also developed themselves in the two fields and they particularly took the role of subject matter experts in subsequent phases. The creation of the need to open the field to experts in subject matter as a research setting opened new horizons to new researchers.

It was an anchor in the research that driving questions remained the same despite the whole complexity of the process and despite the fact that it was introduced in different stages of each cycle. Likewise, in this research the driving question became one of the most significant design-based research characteristics under the control of the researchers throughout the process.

There was also a social context of this study and it was basically built around the campfire. Collins, Joseph and Bielaczyc (2004) evaluated Brown and Campione's (1994, 1996; Brown, 1992) FCL classrooms model as an example of design research. According to them Brown and Campione found that important social goals had been achieved by the design. Students came to value the expertise of others and they worked together better when they appreciated others' contributions. However in this study the expertise of civil defence enriched the social context and with this expertise the campfire appeared to be the centre of social context which consisted of nature awareness, responsibility, apprenticeship and collaboration. It was the venue where the participants ate, talked and felt safe. This social context was transferred to the class with ill-structured problem cases narrated with the aid of photographs and then physics content replaced the social context in the solution process.

The whole process was effective on the solution of the campfire problem. The differences between the cycles reflected on the solution and thus it was different in each cycle.

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SEIZURE OF ATMOSPHERIC CO2: A TEACHING METHODOLOGY AIMING FOR SUSTAINABILITY

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Abstract: The environmental crisis affecting the planet requires that the school search with the teaching methodologies acts in search of sustainability. This study involved seventy-five academics and aimed to develop a simplified methodology for an interdisciplinary teaching, aiming to Environmental Education for Sustainability. This methodology is sought to quantify the carbon stored in the stems of native and exotic trees, to emphasize that the obtained data can be used to support the choice of species in projects that seek to mitigate the greenhouse effect, and with features that help in recovery degraded areas. For the selection of species was based on a literature that showed the relevant characteristics of ecological and trade them. By determining the individual weight and mass density of seeds of each species, along with measurements of height, diameter and volume of adult stem was determined with the use of stoichiometric calculations the efficiency of removal of atmospheric CO_2 for each selected species . Native species have a relevant potential for carbon sequestration, as well as advantages for reclamation. This methodology allowed the experience of interdisciplinary scientific discussions in the classroom, leading students to bring their own understanding of environmental issues for the chemistry, physics, mathematics and biology disciplines, to the positions in the daily life, recognizing that beyond the technical and scientific training for the involvement of other equally important elements.

Keywords: Teaching Methodology. Carbon Sequestration. Native Species. Exotic Species. Science, Tecnology and Society (STS)

INTRODUCTION

The environmental crisis affecting the planet requires that the school search with teaching methodologies acts in search of sustainability of the earth. Observe that you can invest in a new citizenship through a learning formation involving Science, Technology and Society (CTS) is made to interact with the social rationality experiencing technical-scientific rationality decision-making more participatory methods (SANTOS, 1999).

It is a fact that burning fossil fuels and fires resulting from deforestation, which occurred with greater intensity in the last 150 years due to industrial revolution and population growth have been the major cause of carbon dioxide (CO_2) emissions into the atmosphere (GOLDEMBERG, 1998). This gas, along with others, such as water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs), are known as greenhouse gases (GHGs), which form a mixture of gases retain solar heat in the atmosphere.

The greenhouse effect is a naturally occurring phenomenon. The layer of atmospheric gases have a vital role in how solar radiation interacts with the Earth, causing the temperature remains steady and there is life on the planet (SCARPINELLA, 2002), but the model of production and energy consumption has been adopted greatest contribution to the anthropogenic forcing of climate due to the intensive use of fossil resources are not renewable. The amount of carbon released by burning fossil fuels is accelerating, but the kidnapping of the same amount of fossil carbon in the environment, took millions of years to form these fuels (CALDAS, 2004).

Rocha (2002) notes that "the Clean Development Mechanism - the CDM, have a double objective: the reduction of GHG emissions and / or carbon sequestration, and promote the sustainable development of the country hosting the project.

Within the context of the CDM, has been taken into account the importance of forests as a compensatory measure the emission of greenhouse gases. It is scientific consensus that global forests are important for the global carbon balance, as stored in trees and soil carbon more than what currently exists in the atmosphere (HOUGHTON, 1994). For Brazil, in particular the Clean Development Mechanism can be very interesting, since it takes a great potential for Brazil to produce clean energy, and allows the country to play important role in international environmental (VIDAL, 2003).

The plants, using its photosynthetic capacity, fix atmospheric CO_2, biosynthesized in carbohydrates form, and finally deposited in the cell wall, process known as "sequestration" of carbon (RENNER, 2004).

Brazil has the largest diversity of the world. The lack of technical direction and ecological awareness in the exploitation of our forest resources has caused irreparable damage and ecologically valuable species are endangered (LORENZI, 1998). Given this focus, Brazil may take a privileged position in relation to countries that seek to reverse the process of global climate change.

OBJETIVES

This study objectives to build a teaching methodology that allows simplified review and assess the photosynthetic efficiency in the removal of atmospheric carbon dioxide using native and exotic trees, seeking to obtain meaningful data for selection of plants with significant potential for carbon sequestration.

TEACHING METHODOLOGY

This study was conducted with seventy-five students in the Bachelor of Biology course, with emphasis in Ecology, in Canoas-RS-BR, aimed to arouse the awareness of students in order to the problem of climate change, by building an interdisciplinary methodologies for education that promotes the search for alternative solutions aimed at sustainability and the mitigation of anthropogenic environmental effects.

Through literature research using journals, books, papers and publications were researched the characteristics of plants from native and exotic species in relation to their needs change, parameters of soil quality, ease of obtaining germination of the seeds, and forms of plant propagation and establishment of growth time.

Considering that the main components of the tree trunk are polymers consisting of carbon, hydrogen and oxygen, in proportions represented by monomer CH_2O, we used this as the basis for the stoichiometric and statistics calculations, aimed at simple teaching, easy to understand by students and to demonstrate the photosynthetic mechanism of removal of atmospheric CO_2.

Through the characterization of the selected species and literature based on survey data, we selected species with appropriate characteristics to the soil and climate of Rio Grande do Sul, Brazil. The literature data, stoichiometric calculations and statistics were used in calculations of CO_2 remove potential from each selected species. We selected the native trees called <u>Cabreúva-amarela</u> (*Myrocarpus frondosus*), <u>Brazilian Cedar</u> (*Cedrela físsilis Vell*), Brazilian Pine (*Araucária angustifólia)* and Louro Pardo (*Cordia trichotoma*) and even the exotic Pinus (*Pinus elliotii*) and Eucalyptus (*Eucalyptus grandis*).

RESULTS

According to the calculations used to estimate the efficient removal of atmospheric CO_2, based on the equation of photosynthesis monomer, it was found that the species most remove and quantify its trunk in atmospheric CO_2 during its development period until the climax *Araucaria angustifolia* were the native and exotic *Eucalyptus grandis* (figure 1).

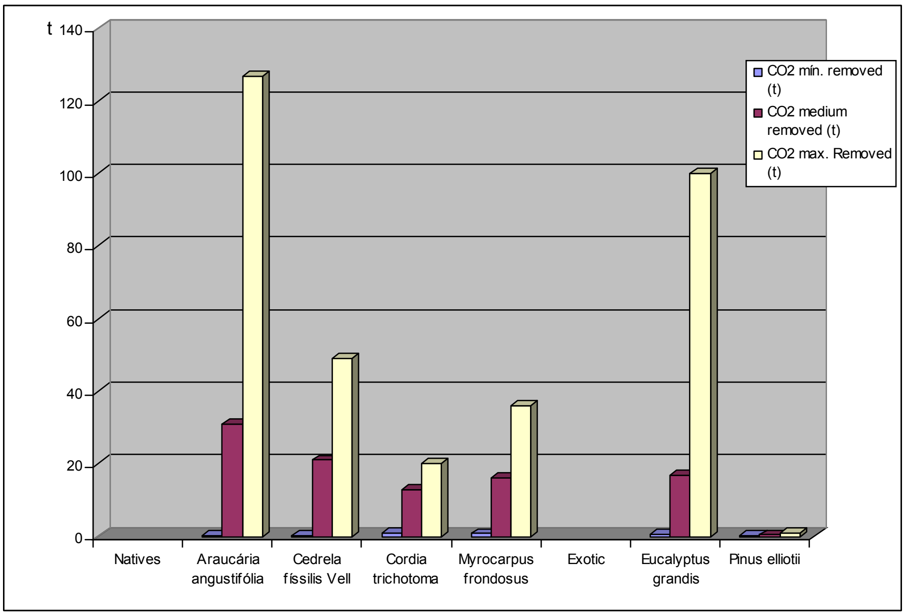

Figure 1. Minimum, average and maximum values of Co2 removed potential (in tons) for each species in study.

The applied methodology provided to the students the agreement of the relation of applicability of the theory in the practical one, enabling them to take it decisions in its future professional life, in relation to the atmospheric carbonic gas removal potential by the more efficient species, aiming at the Sustainable Development.

CONCLUDING REMARKS

The results of this study confirm that native species have significant potential to remove atmospheric CO_2, compared with the principal alien used for timber and pulp industry, taking into account soil and climatic characteristics and possibilities that each one offers.

The research has been useful to scholars, to compare the ability of atmospheric carbon removal between species, to enable scientific discussions branches based on the Science, Tecnology and Society - STS movement, which allowed closer understanding of the theme developed in the academic disciplines to the positions they occupy everyday life, recognizing that beyond the technical science there are other equally important elements to their training.

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ENVIRONMENTAL IMPACTS AND EDUCATION FOR SUSTAINABLE DEVELOPMENT IN PUBLIC SCHOOL

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Abstract: Projects in Environmental Education (EE), developed in schools, aimed at forming an environmental conscience, trying to modify the human relationship with nature and achieve a balance to promote Sustainable Development (SD). The pedagogical activities of EA, for its interdisciplinary character, enclose environmental and exact sciences, social and cultural subjects, political, ethical, historical and others. The principles of EA declared in Tbilisi Conference (UNESCO & UNEP, 1978) have included the key elements for the DS: the need to consider the social aspects of the environment and relations between economy, environment and development, the adoption of local and global perspectives and the promotion of international solidarity and others. Because knowledge is a human construction and depends on the interaction between individuals, working in the school's approach to historical topics of the environmental sciences, can motivate students to ask questions and be more critical relationship to the presented information. Only with the active participation of various society sectors, committed to planning a desire for positive change, that one becomes possible to revert the current model and to seek social justice and environmental balance (DIAS, 2004). This project ,based in action research methodology, aims to develop the teaching strategies in Environmental Education for Sustainable Development, with the target population attended by public schools in the outskirts of Canoas-RS/BR.

Keywords: Environmental Impacts. Education for Sustainable Development. Environmental Education. Pedagogical Strategies.

INTRODUCTION

For Mendes (2006) and Leff (2006, 2002) Sustainable Development occurs when there is effective balance between technology and environment, revealing to the various social groups of a nation and also the different countries in search of equity and social justice. Towards effective Sustainable Development although, second Leff (2006), would require building styles of development based on a new "productive rationality", so that the dominant economic policy incomes in the creation of poverty reduction politics and programs to strengthen productive self-management, with regard to the relationship of dependence that keeps with the state.

There is almost unanimous consensus that the guidelines point toward the formation and empowerment of communities, whether for self-management, is for reorganize the productive arrangement. For Sauvé (1997), Environmental Education is closely linked to Sustainable Development, and production subsidies for the organization and development of new methodologies to be applied in the training of professionals in environmental education, emerged in the theoretical and practical truly interdisciplinary experiences. Is both feasible and practicable, that environmental education included in the Tbilisi Conference (UNESCO & UNEP, 1978) already included the key elements for Sustainable Development: the need to consider the social aspects of the environment and their relationships between the economy, environment and development, the adoption of local and global perspectives and the promotion of international solidarity, the humanistic approach, etc.

In Brazil there are laws like the 9795/99 and 4281/99 decree establishing guidelines and criteria that will encourage and enforce the environmental education efforts. This Act 9795/99 trats of the National Environmental Education and Decree 4281/02 that regulates the National System of Environment (SISNAMA). There are also documents as the Treaty on Environmental Education for Sustainable Societies and Global Responsibility prepared during the ECO-92, signed by several countries, aiming to guide the environmental education practices around the world, and also international documents such as those generated in Stockholm (1972), Tbilisi (1977), and the Global Agenda 21 (1997), somehow both recommend that the EE should have an interdisciplinary and humanistic approach and be developed at all levels within and outside schools.

In studies of Grün (2000), there is a very pertinent question to debate. The appreciation of the concept and the tradition within educational theory can contribute to the integration of environmental education in culture and language, making it something organic and common to a given bioregional medium. However it is observed that in school, Environmental Education becomes possible and timely, appearing as a phenomenon that occurs due to biotic or abiotic interference or large commotion in front of an imminent catastrophe. This coincidence, coupled with the lack of integrated planning and scheduled projects that contribute to environmental education is seen as superficial and fleeting.

It is therefore necessary to identify human actions and their environmental effects in the region and at school, researching historical interferences, economic and social changes that allow to define and analyze the environmental impacts generated by urban sprawl, then propose to develop and invest in Environmental Education for Sustainable Development and healt. By analyzing these factors we chose to use different teaching strategies, seeking an interdisciplinary context as practical classes and field trips, investigating the possibility of incorporating the students' practice and reflection on actions related to the surrounding environment, emphasizing the importance to their life quality by developing themes of the EE for the exercise of citizenship with environmental responsibility.

OBJETIVES

This project, based in the methodology of action research, aims to develop the teaching strategies in EE for Sustainable Development, with the target population attended by public schools in Canoas-RS/BR, through the following objectives:

- use different teaching strategies, seeking an interdisciplinary context as practical classes and field works;

- investigate the possibility of incorporating the students practice and reflection on actions related to the surrounding environment;

- emphasize the importance to their life quality by developing themes of the EE for the exercise of citizenship with environmental responsibility

METHODOLOGY

This work is grounded in action research, a kind of empirically based social research, designed and carried out in a closed association with an action or collective problem solving, in which researchers and representative participants of the situation or problem are involved in a cooperative or participatory action (THIOLLENT, 1997).

The steps hab been: detection of the problem, interaction, theme generation, monitoring decisions and actions, problem solving and the level of consciousness. Data collection was performed using the search to the theoretical framework, environmental zoning, collecting historical data and regional environmental impact studies, field works and photographic records. We also developed experimental activities with the target population, initiated with the implementation of a Data Collection Instrument (DCI) involving students in the School Hall Carlos Drummond de Andrade, in classes 5 and 6 years of elementary school. The DCI used was a questionnaire for population characterization and socio-environmental knowledge, including the health subject.

After, we used lectures and videos on the socio-environmental issue facing the regional reality, in order to rescue the historic formation of the district and establishment of the local community, encouraging reflection on the current problems. The next action was to encourage students to search information on the socio-environmental problems, usually found in their homes or in the coverage areas, stimulating the construction of personal experiences in this regard.

RESULTS

The results led to the realization of a Science Fair where participants socialized their experiences on the covered topics (Figures 1 and 2). To evaluate the results of this action research, we applied a new DCI, to evaluate the methodology applied. We identified a severe deficiency in the students' knowledge construction about the environmental impacts caused in his neighborhood.

Figure 1. Students Presenting results to the GARBAGE problem

After the accomplishment of the sensitization speak and videos exposition, was observed an increment in interest on the thematic, that culminated in the exposition of works made by students in the sciences fair.

Figure 2. Objects confectioned with recycled residues

For this fair, other pupils groups and residents of the district also had been invited as visiting, aiming to increase the scope of the impact of the methodology applied in the school.

CONCLUSIONS

The study enabled the observation of a sharp increase in the perception of environmental issues by the school community involved. We can affirm that developed a pedagogical action beyond the classroom, in a dynamic and opened study to social and cultural diversity, which attracted, involved and is appreciated by students, that working with commitment and social responsibility.

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INFLUENCE OF A NON-FORMAL ENVIRONMENTAL EDUCATION PROGRAM (GREEN COUNCIL PROGRAM) ON PUPILS' ENVIRONMENTAL LITERACY

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Abstract: One solution implemented by schools in Israel to conduct value-based environmental education is outsourcing- allocating out-of-school environmental organizations that develop and conduct environmental education programs. This study addressed such a program - the Green Council Program (GCP) developed and implemented in schools by the Israeli Society for Protection of Nature. It investigated, in a pretest-posttest design, influence of participation in the GCP on components of junior high-school pupils' environmental literacy. Conceptualizations of 'environment', environmental attitudes and sense of ability to act on environmental issues were studied employing quantitative and qualitative tools.
The program did not develop a systemic understanding of 'environment': pupils perceive the environment mainly in biophysical terms and this remained changed, and perception of interactions between organisms and their environment through processes of material or energy flows was limited and remained unchanged. On the other hand, the GCP heightened pupils' sensitivity to human–environment interrelationships and developed a more ecological worldview: after the program, pupils demonstrated greater perception of man as part of the environment, increased sensitivity to human impact on the environment and their value for non-human nature moved from an anthropocentric to a more ecocentric orientation. In spite of the fact that pupils' internal locus-of-control increased, when environmental protection entailed personal economic trade-offs, their support was limited and remained unchanged by the program.
Findings of the study provide empirical evidence to effectiveness of the GCP in achieving its stated goals and in developing components of environmental literacy. They also have broader implications with regards to developing and implementing non-formal environmental education programs in schools as extracurricular programs supplementing the school (science) curriculum, and their effectiveness in achieving all the recognized goals of environmental education.

Keywords: Environmental education; environmental literacy, non-formal education, junior high school students, perceptions of environment

INTRODUCTION

Education is recognized as an implementation strategy for achieving sustainable development (UNESCO, 2004). In 2003, sustainable development was formally recognized in Israel as a national policy to be implemented by all Ministries (Ministry of Environment, 2003). Since then, environmental education for sustainability (EEfS) has been included as a goal of education (Ministry of Education, 2004). Challenges for the educational system in responding to prioritizing of EEfS are considerable, such as how to conduct effective EEfS and within which frameworks? Science education is targeted as a main subject for including EEfS and developing environmental literacy is currently recognized as one of the goals of science education. Practical issues arise in addressing meaningful EEfS within science education. For example: standards- based science education compounded by time constraints encounters difficulties in addressing the diverse dimensions of EEfS such as educating for values and developing environmental citizenship. Questions relate to teacher preparation - are science teachers sufficiently equipped to address meaningful EEfS?

One solution schools take to conduct value-based EEfS is outsourcing - allocating out-of-school environmental organizations that develop and conduct environmental education programs as one tool to realizing their goals. This study addressed such a program. The 'Green Council' Program is an environmental education program developed and implemented in schools by the Israeli Society for Protection of Nature (SPNI). The GCP is based on non-formal education attributes (Eshach, 2006) and on the SPNI educational model 'From experiencing wonder to action' (Gan, Pizmony & Peled, 2002) aimed at developing environmental-social activism in young people. The 'Green Council' is a group of pupils motivated to promoting environmental change in their school and local community. These pupils and their teacher convene with an SPNI instructor after school hours throughout the school year to work on local environmental issues. GCP is not part of the school curriculum, is taught by an SPNI instructor and student participation is of free will.

The present research was conducted in a junior high school in the major city of southern Israel that implements the SPNI environmental education program. It aimed to investigate influence of participation in the GCP on components of pupils' environmental literacy. Specifically, the study addressed pupils' understandings of the concept 'environment', their attitudes regarding the value-of-non-human-nature, positions on priorities for resource management and their sense of ability to act on environmental issues.

METHODS

Participants

The study was conducted in a paired pretest-posttest design with 50 7^{th} and 8^{th}grade pupils (25/grade) who participated in the GCP. They were average to strong pupils.

Instrumentation

The study was based on the mixed-methods approach employing a combination of quantitative and qualitative tools. Conceptualizations of 'environment' were investigated with the Draw-an-Environment Test (Shepardson, Wee, Priddy & Harbor, 2007) and the Word Association procedure (Hovardas & Korfiatis, 2006; Ben-Zvi Assaraf & Orion, 2009) in which terms provided by pupils to the stimulus term 'environment' reflect their patterns of thought. Attitudes regarding value-of-nature, positions on priorities for resource management and locus-of-control for environmental action were investigated by a combination of the likert-type environmental attitude questionnaire (Pe'er, Goldman & Yavetz, 2007, Yavetz, Goldman & Pe'er, 2009), written explanations for questionnaire items and the Repertory Grid technique (Bezzi, 1999) which depicts the individual’s way of thinking. In the repertory grid technique, participants randomly chose series of 3 terms from their word associations, for each series chose a term they perceive as exceptional and provide an explanation why.

A combination of tools enabled data triangulation thus enhancing validity of results and providing more comprehensive information on changes occurring in pupils’ environmental literacy.

Data analysis

Shepardson's et al., (2007) typology of mental models of environment was used for analysis of drawings. Different mental models reflect various ways in which pupils perceive 'environment'. Analysis of word associations used an inductive content analysis procedure (Ben-Zvi Assaraf and Orion, 2009). Analysis of repertory grid data was based on Ben-Zvi Assaraf and Orion (2009). For validity, researchers analyzed data individually and only categories agreed upon were included. For quantitative data, means, standard deviations and distributions were determined and paired t-tests were used to examine differences between pre-test and post-test groups.

RESULTS

Perceptions of 'environment'

Analysis of drawings of 50 pupils shows that in the pre-test group the most prevalent mental model (36%) was that which expresses a romantic perception of the environment as pastoral nature in which man has no part. In the posttest there was a 39% decrease in drawings reflecting this mental model. Most pupils, in both the pretest and posttest, portrayed the environment in biophysical terms, as an ensemble of components and very few expressed processes of energy or matter flow. Thirty percent of the pretest drawings corresponded to a mental model which perceives man as part of the environment in a harmonious relationship with other organisms. A 33% decrease was found in this mental model in the posttest in spite of the fact that one aim of the GCP is to evoke a feeling of human oneness with nature. Fewer drawings in pretest group (18%) corresponded to the mental model which perceives the environment as life supporting - a place providing the resources necessary for living organisms, and no change occurred in the frequency of this mental model in the posttest. This mental model reflects perception of interactions between organisms and their environment, hence it expresses a more developed and systemic understanding of the environment, relating not only to tangible components but also to interactions between them through processes basic to sustaining life. This may explain the limited frequency of this mental model. Sixteen percent of the pretest drawings corresponded to the mental model which perceives the environment either as a natural place impacted by man or as manmade. This was the mental model most influenced by the GCP: a nearly 3-fold increase occurred in the number of drawings portraying this mental model after participating in the program.

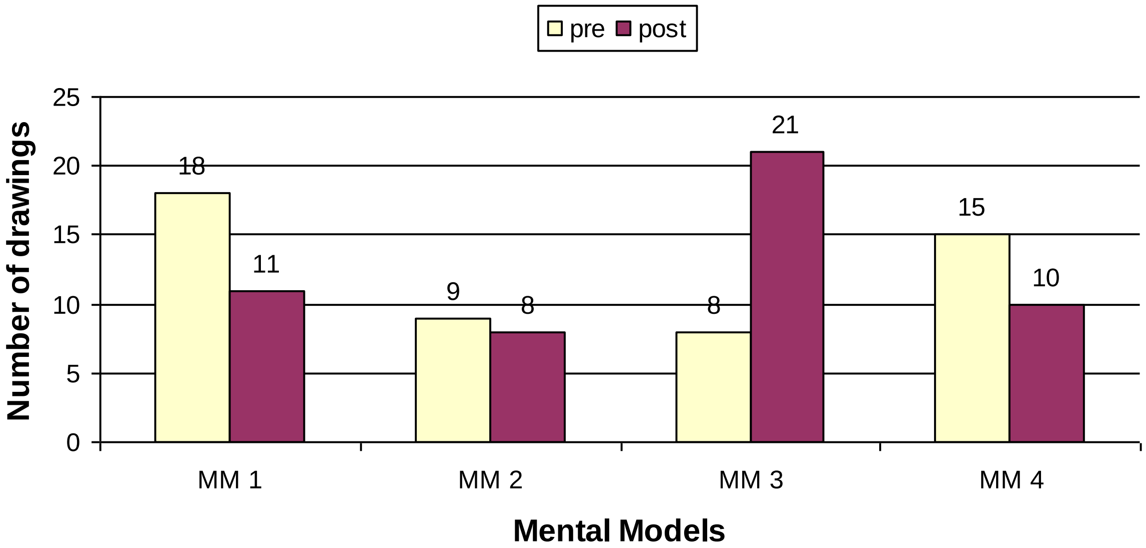

Figure 1. Distribution of students' drawings and explanations of 'environment' based on the Mental Models (MM) described by Shepardson et al., 2007 (MM1 - A natural place where

animals or plants live, MM2 – Supports life, MM3 – A place modified or impacted by man, MM4 – A place where plants, animals and people live).

Content analysis of concepts provided by pupils in their word associations to the prompt term 'environment' revealed four major categories reflecting different ways pupils perceive and understand the concept 'environment': a) biophysical - terms related to physical or biological aspects, describing the environment as an ensemble of components; b) social - terms relating to human aspects of environment; c) romantic - nature, pastoral-related terms; d) environmental protection - terms relating to man's intervention - a place man-managed or in need of protection from human impact. Similar to the results obtained in the draw-an-environment test: 1) The predominant category in both the pretest and posttest was the biophysical (44% and 31%, respectively); 2) Environmental protection was the least frequent pretest category (11%) and the largest change (2-fold increase) occurred in the frequency of this category in the posttest (25%).

Value-of nature

Results of the attitude questionnaire indicate that pupils moved from a more anthropocentric orientation in the pretest to a more ecocentric orientation in the posttest. For example, in the pretest, two thirds supported the position that the value of organisms is determined solely by the benefit they provide man, while in the posttest there was significant decrease in the utilitarian value of organisms ($t=4.36$, $p=.001$). Results of the repertory grid correspond to those obtained in attitude questionnaire: 61% of the constructs created by pretest pupils reflected an anthropocentric approach while in posttest, 63% of constructs reflected an ecocentric approach.

Priorities for resource management

Pupils' support for environmental protection was strongest and most influenced by participation in the GCP ($t=2.53$, $p=.007$) when this was presented as a general priority. Support for environmental legislation that puts constraints on personal lifestyle was less pronounced and change in pupils' position between the pre and posttest was more limited ($t=1.74$, $p=.04$). When implications of environmental protection were demonstrated at a personal level, in terms of trade-offs between environmental protection and economic benefit, or between environmental protection and leisure activities, the students expressed less support for protection and no change occurred between pretest and posttest ($t=1.25$, n.s. and $t=1.92$, n.s.)

Self efficacy to act on environmental issues

Pretest pupils displayed overall sense of self-efficacy to positively effect the environment through their personal behavior and this was further enhanced in the posttest. For example, 40% disagreed with the statement 'Responsible environmental behavior won't make a difference because the impact of others is too great' in the pretest and disagreement increased significantly in the posttest ($t=2.49$, $p=.008$).

CONCLUSIONS AND IMPLICATIONS

This study investigated influence of participation in the Green Council environmental education program on aspects of junior high school pupils' environmental literacy. Regarding comprehension of the environment, results indicate that the program did not develop a more complex understanding of this concept: perception of the environment mainly as an assemblage of biophysical components remained unchanged; perception of interactions between organisms and their environment through processes of material or energy flows, which reflects a more complex understanding of the environment not only in tangible biophysical terms but as processes, was limited and remained unchanged. On the other hand, results indicate that the program heightened pupils' sensitivity to human–environment interrelationships and developed a more ecological worldview. After participating in the program, pupils demonstrated greater perception of man as part of the environment, increased sensitivity to human impact on the environment, and their environmental values, reflected in their value for non-human nature, moved from an anthropocentric orientation to a more ecocentric orientation. One of the aims of environmental education is to move individuals in this direction on the anthropocentric-ecocentric continuum. An important component of environmentally literate individuals is their self efficacy, and one purpose of environmental education is to empower people with belief in their ability to contribute to environmental solutions through personal behavior. Participating in the program increased pupils' internal locus-of-control. The strong sense of self efficacy demonstrated by pupils before the program may reflect attributes of these motivated adolescents and their environmental orientation motivating them, in the first place, to participate in the program. When environmental protection had personal economic implications, pupils' support was conservative and remained unchanged by the program. While this result appears to stand in contrast to their increased environmental sensitivity, it may reflect their limited understanding of the environment. Support for personal sacrifice reflects conceptual awareness of how human behavior affects the environment, i.e. the person understands that resources are limited, comprehends personal implications of conserving limited resources and is willing to make personal sacrifices necessary to conserve resources. And visa versa (Pe'er et al., 2007).

Goals of the Green Council Program focus on the affective components of environmental literacy - environmental values and attitudes. Its focus is not on developing knowledge since the case studies chosen for schools are based on relevant ecological, environmental concepts studied in the science curriculum. Results obtained in the study support contribution of the GCP to developing affective components of environmental literacy. The findings also support the importance of the knowledge component in promoting commitment to responsible environmental behavior as reflected in the willingness for changes in personal lifestyle.

Findings of this study provide empirical evidence to the effectiveness of the Green Council Program in achieving its stated goals. They may have broader implications with regards to developing and implementing non-formal environmental education programs in schools as extracurricular programs supplementing the school (science) curriculum, and their effectiveness in achieving all the goals of environmental education for sustainability.

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FINNISH PUPILS' CONCEPTIONS OF THE IMPORTANCE OF NUTRITION, SLEEP AND EXERCISE FOR THEIR WELL-BEING

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Abstract: Nutrition, sleep and exercise are extremely important factors for health. New studies have shown that obesity is common, pupils do not sleep enough, and their fitness is not good. School-based health education would produce positive effects on beliefs, attitudes and behaviour, if it was known what pupils think about these issues. This paper reports the results of a study where the pupils' conceptions of the importance of nutrition, sleep and exercise for their well-being were investigated. The study was a quantitative descriptive survey, in which a total of 203 pupils (11–12 years old) participated voluntarily. The resultant data was collected using a semi-structural questionnaire in 2009. The data was analysed by using SPSS and Excel and tested with the Student t-test. Based on the results, most of the pupils found their health to be good or very good. They understood that healthy food, sleep and exercise are important. They ate well every day, but more in the afternoons and evenings. The girls appreciated healthy food more than the boys. The pupils thought that sleep is important for feeling well. They slept over eight hours per night. Over 60 per cent thought that exercise is important for welfare, good mood and physical fitness. The boys exercised more than the girls. Based on our results, it seems that the most important topics to be included in the curriculum and in the teaching, learning and studying processes of health education seem to be those which are especially related to mental and social welfare. In addition, significance of rest and sleep to health and the importance of breakfast and school meals for concentration and feeling should be discussed more at school.

Keywords: sleep, nutrition, exercise, health, pupils

INTRODUCTION

Core themes in research are the connections of education with health and well-being (Lappalainen et al., 2008). The most commonly quoted definition of health is that presented in the Constitution of the World Health Organization (WHO, 1996): "Health is the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Well-being has a personal and an objective side. The former consists of one's own experiences of one's health, the latter of external factors such as livelihood, education, safety and social relationships. (Rimpelä et al., 2007) According to Jeronen, Kaikkonen, and Lindh (2008, 111), the majority of 11–12 years old Finnish pupils felt that they were in good health. They explained their good health with lack of illness, good feelings and having the strength to live. Important factors for health are nutrition, sleep and exercise.

Eating habits are adopted in childhood and are very difficult to change (Ojala, 2004, 83). They are affected e.g. by nutrition knowledge, family and peers. The recommendation for the eating cycle is five to six times per day (Pethman & Ilander, 2006, 22). All Finnish pupils in comprehensive schools are offered a free warm lunch at the school refectory every schoolday. Skipping meals appears not to be common among Finnish pupils aged 10–11 years. A considerable proportion consumes sweets frequently and vegetables infrequently.

(Haapalahti et al., 2002) The eating of vegetables and fruits of 11-year-old boys and girls decreased in 1986−2002 (WHO, 2009). The drinking of milk also decreased in 1990−2002 (Ojala, 2004, 92−93). According to Jeronen, Marjeta, and Jeronen (2010), girls appreciate healthy food more than boys.

The sleeping habits of pupils are dependent on their family, friends, school, and their own internal feelings. The length of the sleeping time should be about 9 hours per night (Partinen & Huovinen, 2007, 30). From 1984 to 1990, every tenth 13-year old went to bed earliest at 11 p.m. On average, the length of sleeping time was 8 hours and 15 minutes in 1994−2002. From 1990 to 1998, morning tiredness increased and in 2002, 30 % of the boys and 40 % of the girls felt tired in the morning. (WHO, 2009) Girls were more tired than boys (Tynjälä, 1999).

According to Fogelholm et al. (2007, 26−35), about 90 % of the boys and about 80 % of the girls among Finnish pupils aged 9−12 (n=2255) exercised for at least one hour per day in 2001−2003. In 1986, 40 % of the boys and 20 % of the girls and in 2002, 45 % of the boys and 30 % of the girls had physical activities at least four hours per week (Vuori et al., 2004, 124−125). About half of Finnish children participate in sport clubs on a regular basis, and four children out of five have participated sometimes (Opetusministeriö, 2008, 15). Based on the common recommendations, physical activities should make up 1−2 hours per day (Nuori Suomi, 2008, 17−20). Regular physical exercise has been characterized as a positive health behaviour, having physiological and psychological benefits (Hassmen et al., 2000, 17–25).

The Finnish comprehensive school curriculum framework for years 1–9 defines the aims and key contents of different subjects and thematic entities, and provides guidelines concerning student evaluation. The objective is uniform basic education, i.e. a continuum throughout the years 1–9 (pupils aged from 7 to 15 or 16 years) (National Core Curriculum for Basic Education, 2004). The National Core curriculum forms the basis for drawing up local curricula, which is usually done by the municipalities. Based on the local situation teachers design a curriculum for their schools and pupils taking into account the needs of the pupils and teaching, studying and learning possibilities in the area. For the first time, student welfare has been included in the curriculum. A new school subject is health education, which is to be taught as an independent subject starting in the seventh form. In the forms one to six, health education is incorporated into other subjects such as environmental and nature studies, biology, chemistry, physics; and physical education.

The study is of interest because nutrition, sleep and exercise habits, and especially overweight have developed into a major health concern over the past few decades (International Obesity Task, 2004; Currie et al., 2008; Barnekow & Muijen, 2009; WHO, 2009). Health promoting habits adopted in childhood pave the way for good health in adulthood, and decrease the risk of many diseases. Based on the Finnish Basic Education Act (628/1998): ”The purpose of education … is to support pupils' growth into humanity and into ethically responsible membership of society and to provide them with knowledge and skills needed in life.” Researchers have shown that school-based health education is capable of producing positive effects on beliefs, attitudes, and behaviour (Downie *et al.*, 2000, 111). For the development of school-based health education, it is important to know the conceptions of the pupils, because these conceptions have effects on the learning of new issues and on the construction of new conceptions (Sormunen, 2004).

The main purpose of the present study is to describe young Finnish pupils’ understanding of their own nutritional, sleeping, and physical exercise habits. In addition, it will be studied how these conceptions are different compared to their everyday life behaviour and the nutritional and physical exercise recommendations.

The following research questions guided this study:

1. How do the pupils understand the concept of well-being and how do they experience their own health?
2. How do the pupils understand the effects of eating habits on their well-being and what kind of eating habits do the pupils have?
3. How do the pupils understand the effects of sleep on their well-being and what kind of sleeping habits do the pupils have?
4. How do the pupils understand the effects of exercise on their well-being and what kind of exercise habits do the pupils have?

MATERIAL AND METHODS

This quantitative descriptive survey involved a total of 203 pupils (11–12 years old, 107 boys and 96 girls) from two primary schools in northern Finland (Hirsjärvi et al., 1997, 189). The pupils participated voluntarily in the study. The data was gathered using a semi-structural questionnaire in the autumn of 2009. At the beginning, the pupils were given guidelines and a possibility to ask about the questions. Then they were given 20 minutes to complete the questionnaire. The resultant data were analysed quantitatively using SPSS and Excel, and were tested with the Student t-test.

RESULTS

Based on the results, the pupils considered the concept of health from the physical point of view (Fig. 1). They linked it with regular exercise, healthy eating habits, good condition, and sufficient sleep. Most of them also linked health with social relationships. However, it seems that the pupils understand health mostly as a physical condition and that for them, health as a state is the opposite of illness. All the pupils felt that their own health was good.

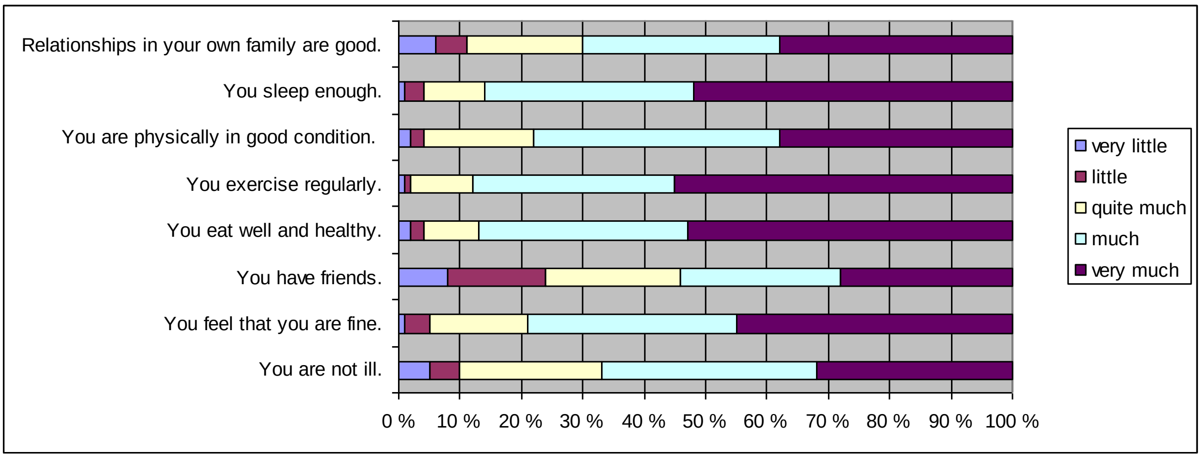

Fig. 1. The pupils' conceptions of health.

Based on the pupils' answers, food is important for feelings and health (Fig. 2). They did not emphasize nearly at all its meaning for concentration, mood, and weight management. 98 % of the pupils informed that they eat both lunch and dinner, but more in the afternoons and evenings. The girls appreciated healthy food more than the boys. However, the difference between the groups was not statistically significant.

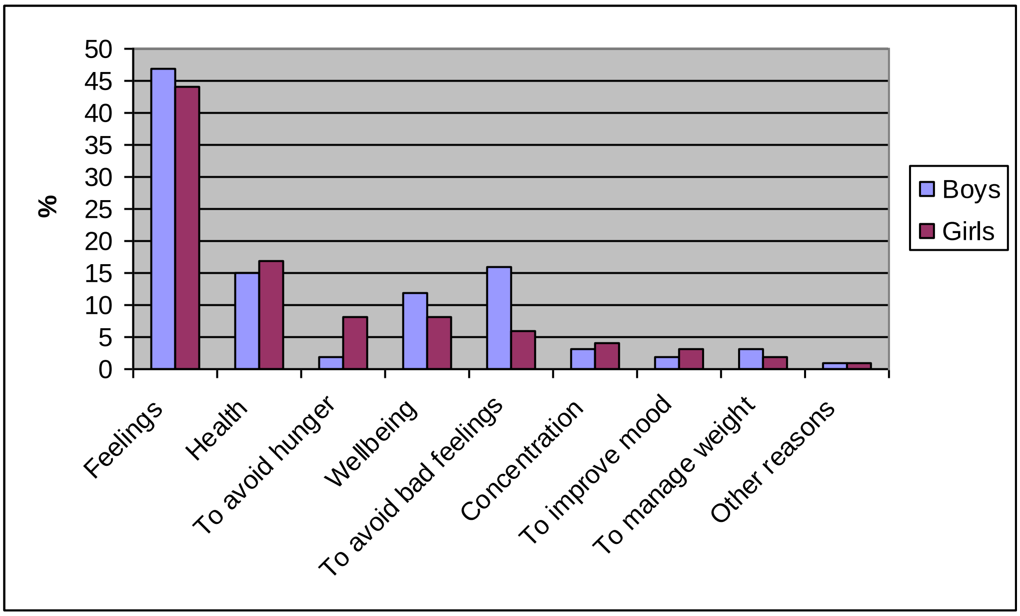

Fig. 2. The pupils' conceptions of the effects of eating on their well-being.

The sleeping habits were investigated by asking how sleep and well-being were linked with each other, and at what time the pupils went to bed in the evening and woke up in the morning. Most of the pupils stressed the importance of sleep, saying that it supports a good feeling (Fig. 3). Quite a few pupils also maintained that it helps concentration and improves their mood. Only some of them observed the importance of sleep for health and well-being. The pupils slept for 8 hours and 15 minutes on average.

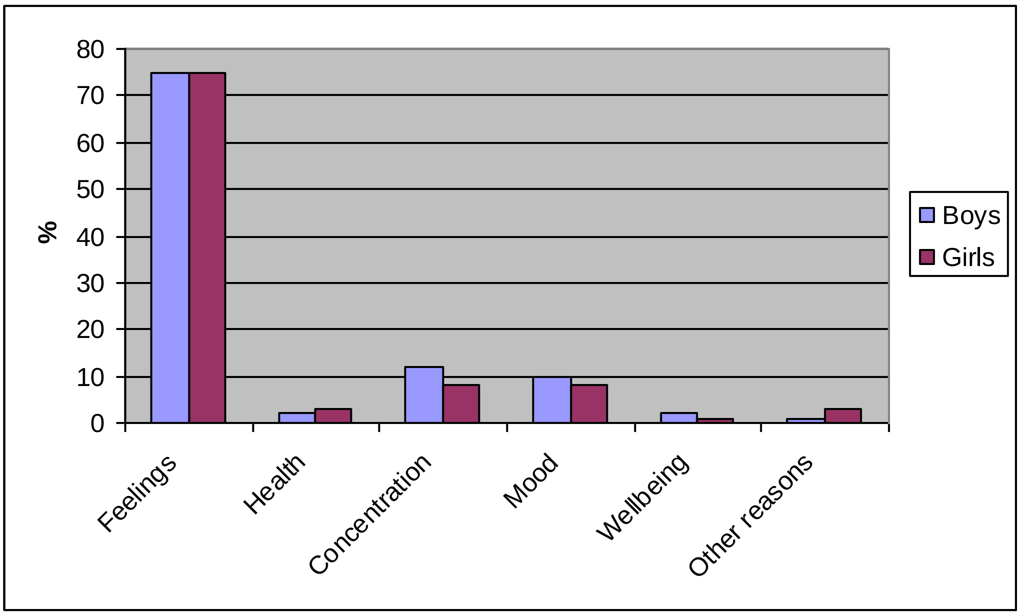

Fig. 3. The pupils' conceptions of the effects of sleep on their well-being.

The pupils linked exercise with fitness, good mood, power, and better health (Fig. 4). The boys stressed more the effects of exercise on well-being than the girls. They also had more exercise than the girls. Only a few boys and girls linked exercise with sleep and concentration. No statistical differences between the groups were found. 50 % of the boys and girls participated regularly in physical exercises at school, in their spare time and in exercise clubs.

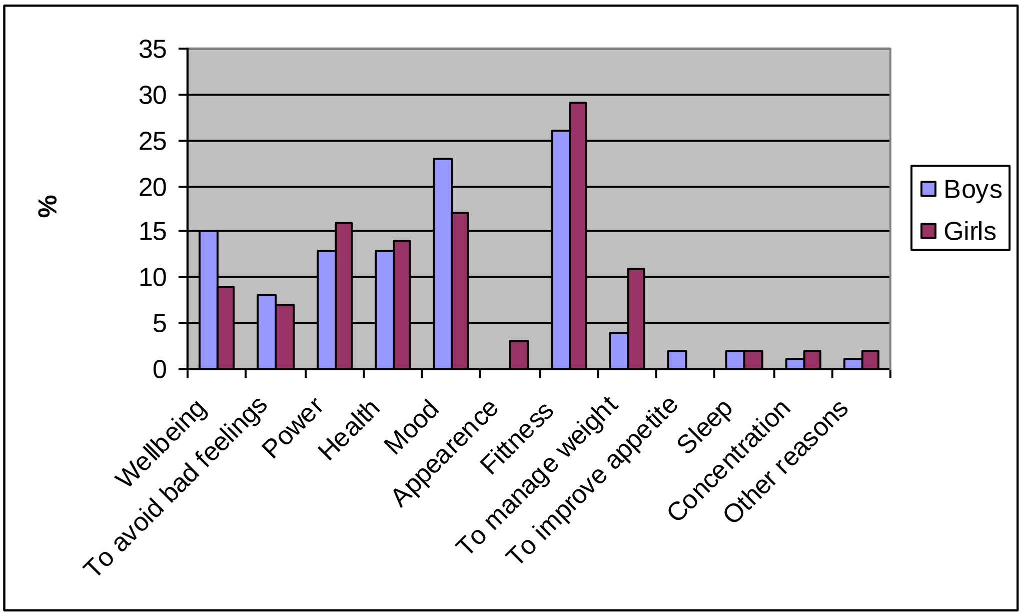

Fig. 4. The pupils' conceptions of the effects of exercise on their well-being.

CONCLUSIONS AND IMPLICATIONS

An important outcome of the study is the information gained about the understanding that pupils have about health. These issues are important in the context of planning and reconstructing school environments and curricula of health education. The pupils understood health mainly as a physical condition, i.e. in the same way as it is determined by WHO (1996). The central basis for learning and developing is how pupils feel about the state of their health (Kemppainen, 2001). The pupils thought their own health to be good. The result supports the findings by Jeronen et al. (2008).

The pupils' eating habits are in accordance with the common recommendations. The finding that the girls appreciated healthy food more than the boys supports the result of Jeronen et al. (2010). The reason may be that Finnish girls work more in the home kitchen than boys do.

According to Tynjälä (1999), unhealthy sleeping habits, sleep difficulties and tiredness emerged with increasing age. Gender was an important explanatory factor of sleeping habits and sleep difficulties. In our study, the sleeping time of the pupils was in accordance with the common recommendations, and no differences were found between boys and girls.

All the pupils had a sufficient amount of physical activities in terms of the exercise recommendations. They participated regularly in physical exercises at school, in their spare time and in exercise clubs. The results support earlier studies by Fogelholm et al. (2007) and Opetusministeriö (2008).

The results of the study seem to be quite reliable. The questionnaire was pretested with 20 pupils aged 10-11 who did not participate in the study. Two of the researchers co-operated throughout the study. Co-operation has positive effects on the quality of a study (Soininen, 1995, 120). Our results also supported existing results in the literature. However, due to the small number of respondents the results cannot be generalized.

It is important to realize that the physical, mental and social dimensions of health are interconnected with each other. Health education should support pupils' holistic growth and development of health-promoting behaviour. Based on our results, the pupils follow the nutrition, sleeping and exercise recommendations well. The importance of breakfast and the school meal for concentration and feeling should be discussed more at school. The most important topics to be included in the curriculum and in the teaching, learning and studying processes of health education seem to be those which are especially related to mental and social welfare. In addition, the significance of rest and sleep for health should be emphasized. If it is an objective of health education that pupils have skills such as recognizing their abilities and reflecting on their own knowledge and attitudes, pupils should be allowed to participate not only in carrying out the processes in the lessons but also in the planning and evaluation of their studies. Development of health awareness should be based on conscious experiences, ideas, beliefs, and knowledge. In this connection, knowledge does not only mean facts and concepts but also understanding of phenomena and their relations, as – besides theoretical knowledge – pupils also construct new knowledge through action. Efficient health education also requires that parents participate and work together with the members of the school community. Thus the ability of pupils to make healthy selections, to care for their own health, and to take social relationships into account in everyday life will improve step by step.

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EXPERT TEACHERS' TEACHING MODELS OF LIFE-CYCLE THINKING IN CHEMISTRY INSTRUCTION – A DESIGN RESEARCH

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Abstract: The aim of this design research is to improve the quality of teaching of life-cycle topics in chemistry instruction through in-service training. The novel course provided information on different aspects of life-cycle thinking in chemistry, and inquiry-based learning. The aim of this course is to support students' positive attitudes towards chemistry, and conservation of environment. The research questions in the first phase of this design research were: (i) what kind of teaching models do expert teachers from secondary and high school level develop during a short in-service training course related to life-cycle thinking in chemistry, and (ii) what kind of feedback do the trained teachers give on the usefulness of the course? As a result of this case study, the topics of teaching models developed by four trained expert teachers included: the life-cycle of cotton, water, and an optional subject generated from student interest. According to the teachers' feedback, this kind of environmental course was beneficial for them. The next phase of this design research is to study the implementation of the developed models in practice at school.

Keywords: design research, case study, in-service training, life-cycle thinking, inquiry-based learning

INTRODUCTION

Environmental aspects are more and more important in education of children and young people around the world. Teachers have requested improvements to the field of environmental teaching design and green chemistry (e.g. Taskinen, 2008; Lumivaara & Aksela, 2002; Feierabend, Jokmin & Eilks, 2011). Chemistry teachers have described that the teaching of environmental matters is currently more general than in-depth. They have also cited that the topics are taught with little relevance to the students' everyday life. One aim of Finland's curriculum in chemistry is to promote variable learning skills typical to science, and to identify the life-cycles of products and substances, and their importance to the environment and nature (Finnish National Board of Education, 2004). Also pupils' abilities to use chemistry knowledge in promoting health and sustainable development as a consumer, and in discussion and decision-making are evaluated (Finnish National Board of Education, 2003).

From chemical perspective, life-cycle thinking combines green chemistry and engineering. It is an approach that evaluates the environmental burden of a product, process or activity. By quantifying resource use and emissions, and assessing their health impacts, it is possible to find possibilities for improvements (Anastas & Lankey, 2000).

From educational perspective, life-cycle thinking is a socioscientific teaching approach.

The educational applications of it have not been studied earlier. In teaching, socioscientific issues focus on empowering the students to consider how science-based issues reflect moral, social and physical world around them (Zeidler, Sadler, Simmons & Howes, 2005). Like Marks and Eilks (2009) point out, by implementing various relevant and controversial socioscientific issues into science teaching, it is possible to provoke and allow open discussion and individual decision making processes. In practice, teaching methods may include e.g. learner centred instruction, cooperative learning, use of authentic media and controversial debate. The aims of socioscientific and critical approaches are to promote students' motivation, improve their attitude towards chemistry in general, and reach a broad range of educational goals in personal, cognitive and moral development (Zeidler et al., 2005; Marks & Eilks, 2009).

Many studies have highlighted an alarming decline of interest in key science subjects among young people in Europe (Rocard, Csermely, Jorde, Lenzen, Walberg-Henriksson & Hemmo, 2007). The attitudes of young people towards studying chemistry have changed to more negative also in Finland in the short run (e.g. Asunta, 2003).

Educational research points out the benefits of increasing inquiry-based teaching methods, as used in this in-service training. Inquiry-based education has been proven to support the young peoples' interest to study more science (Rocard et al., 2007; the Inter Academy Panel, 2010; Colburn, 2000). For students' motivation, it is likely important that chemistry education is closely related to their everyday life and surrounding society (Marks & Eilks, 2009; Rocard et al., 2007). By combining socioscientific issues, like life-cycle thinking, to inquiry-based learning methods, it is possible to support the pupils' interest and variable skills in science (Marks & Eilks, 2009).

METHODS

The aim of this design research was to improve the quality of the teaching of life-cycle topics in chemistry instruction through an in-service training course. The course is studied as a case study and it is the first phase of the design research (Edelson, 2002). It includes a theoretical problem analysis and an empirical problem analysis. The research questions were: (i) what kind of teaching models do expert teachers from secondary and high school level develop in a short in-service training course related to life-cycle thinking in chemistry, and (ii) what kind of feedback do the trained teachers give on the usefulness of the course?

In the theoretical problem analysis, Finnish chemistry textbooks and science curriculum were analyzed by content analysis (Tuomi & Sarajärvi, 2006). The words "life-cycle", "ecological pack bag", and "footprint" were searched from the curriculum and books, and classified according to their place in text, and picture, chart, or exercise setting. Secondly, the inquiry level of the exercises was evaluated as structured, guided or open inquiry (Colburn, 2000).

In empirical problem analysis, four expert chemistry teachers voluntarily attended an in-service training course, which was implemented in two parts (2 days + 2 days). The course included e.g. discussion about the possibilities of green chemistry as an answer to environmental crisis, information on different production processes with regard to pollution and consumption, introduction to inquiry-based education concept, green chemistry related school laboratory experiments, specialist lectures, and visits to waste water plant and green chemistry laboratory. After two course days and based on the discussed topics, teachers got a task to write an open, inquiry-based report. The aim was to improve their own teaching related to life-cycle thinking and inquiry-based learning. They created three “raw” teaching models that were collaboratively developed into more inquiry-based direction during the course with the other teachers and with few chemistry education researchers. A similar collaborative design of sociocritical chemistry teaching models has been described in participatory action research by Marks and Eilks (2009).

In empirical problem analysis, the focus was on three teaching models created by the in-service trained teachers. In content analysis, the models were classified according to whether they had already fulfilled the goals set to them. If not, the teachers collaboratively designed their models further. The goals of the model were similar to those of Marks and Eilks’s (2009). It should:
- use inquiry-based approach
- reveal the relevance of chemistry in environmental protection, as well as in political discussion and decision-making
- motivate and inspire the pupil to protect environment and study chemistry
- develop skills for cooperative studying, critical thinking, problem solving, communication, and evaluation.

A structured 5-point Likert feedback questionnaire of the Finnish National Board of Education was used to evaluate the teachers’ opinions after the course. The statements in the questionnaire included evaluation of course content, training methods, teachers' learning outcome, and lectures of the course topics given by specialists from various fields. To get a wider view on the teachers’ thoughts, also three open pre and post questions were asked: 1) Describe the concept “inquiry-based learning” in your own words? 2) What kind of factors are included in “life-cycle thinking”? 3) Give comments on the course, ideas and wishes.

RESULTS AND CONCLUSIONS

The research questions were answered by the following results. Four in-service trained expert chemistry teachers developed and tested three novel student-centered teaching models (see Table 1). The models combined life-cycle thinking and inquiry-based learning approach for secondary or high school purposes.

Table 1. Three teaching models created by the in-service trained teachers.

Teaching model	Goals of the model	Implemen-tation	Level
Life-cycle of an optional product	To investigate and analyze the life cycle of a product by using internet, experts’ help and peer review. Finally, a presentation of the project works.	2–3 students, 6 x 75 min	upper secondary or high school
Life-cycle of water	To investigate and analyze water cycle in nature and become familiar with (waste) water purification.	2–4 students, 4 x 45 min	high school
Life-cycle of cotton	To create an info table about the environmental effects of T-shirt production and usage.	2–4 students, 5 x 45 min	polytechnic (or high school)

The designed models discuss a life-cycle of cotton, water, and an optional subject. They are inquiry-based and student-centred. The students take responsibility for themselves and decide, what is important for them to investigate. Depending on the students' skill-level, the teaching models can be implemented as structured, guided, or open inquiry (Colburn, 2000).

The models use variable learning materials, methods, and ways of working including pair or small group work, and opponent review. This is similar to what is described by Marks and Eilks (2009). Only difference to their sociocritical teaching models is that "clarifying chemistry background in a laboratory environment" is almost absent in the presented models. As the time is limited in lessons, the trained teachers designed their models to emphasize students' question-making, cooperative information search, critical discussion, peer review, and presentation of the findings. They even suggested a conference-type gala evening to conclude the students' work.

Similarly as described by Kolsto (2011), socioscientific issues with different levels of complexity involve and develop different kind of competence. Also here, the trained teachers focused the evaluation of students' outcomes more on the research process than on the factual knowledge.

This type of in-service training course can be used to train more teachers. In the 5-point Likert feedback questionnaire, the teachers graded the course as good (4) or very good (5). They reported to recommend this type of a course to their colleagues. In the open questions, they described the course as "beneficial" and "giving new ideas". The analysis suggests that the trained teachers gained new competence to guide their students through the topics of life-cycle chemistry using inquiry-based methods of learning. Four teachers attended the prototype of the in-service training course. In a larger group, the teachers would benefit more from each other's knowledge and opinions.

In general, a design research produces a design solution that here are the three teaching models. Besides, it also generates knowledge about the design process and the domain itself. (Edelson, 2002) Thereby, the next step is to further develop a synthesis model of these and to study the developed models in practice at school (e.g. Marks & Eilks, 2009). After the course, the teachers are encouraged to test their novel teaching model in a school setting with their students. However, the teachers are still missing an inspiring in class introduction to the concept of life-cycle thinking with green chemistry examples (e.g. Anastas & Lankey, 2000). One possibility is to design it collaboratively with teachers or student teachers in the subsequent phases of the design research.

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AN INVESTIGATION OF ENVIRONMENTAL RISK PERCEPTIONS OF PRIMARY AND SCIENCE PRE-SERVICE TEACHERS

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Abstract: Environmental risk is a phenomenon arising either from natural or man-made reasons at local or global levels. Environmental risk perception, on the other hand, for the solution of environmental problems and reducing the risks threatening the environment is an important step to increase awareness of an individual and society. For this reason, exploring individuals' and society's environmental risk perception is important for environmental education. The main purpose of this study is to investigate the primary school teachers' perceptions of environmental risk. In addition, it also aims at finding out whether student teachers' perceptions of environmental risk change based on gender and according to program of study in which they were enrolled at the time of study. Research was carried out with 204 teachers enrolled both in Science Education and Elementary education program in Faculty of Education at Siirt University. Instrument for this study was originally developed by Slimak and Dietz (2006) and was translated into Turkish by Altunoğlu & Atav (2009) entitled as "Environmental Risk Perception Scale". In our study, the internal consistency Cronbach's alpha coefficient was found to be 0.89. Also, teacher candidates' perceptions of environmental risk were found to be moderate, and high awareness of environmental issues was identified.

Keywords: Environmental, education, perception, preservice teacher, risk

INTRODUCTION

Environmental problems could be defined as accumulation of factors detrimental to living organisms' living and behaving patterns. These are mostly man-made such as ozone depletion, air and water pollution, acid rains, global warming, excessive fertilization, pollution of rivers, deforestation, climate changes, greenhouse effect, and extinction of some species. Rapid spread in industrialization and consequent increase in people's living standards have also resulted in environmental problems we all likely have to encounter in our daily lives. Although scientists and environmentalists highlight the scale and intensity of environmental problems, there does not seem to be enough will on the people's part to confront these problems. According to Erten (2004) in today's world environmental problems cannot easily be solved by technology or new legislations but by changing people's perception of them. In this regard, Soran and et. al. (2000) suggests that environmental education should start at pre-school age for children, thereby making them aware of dangers posed by environmental disasters. Ayvaz (1998) also claims that there is a direct link between awareness for environment and getting ready for action to minimize the bad effects of environmental disasters. Consciousness for environmental issues can be wide-ranging, entailing the interplay between ecologically responsible people and high sensitivity to environmental problems. In this framework, we could summarize that there is a social aspect for solving environmental problems. The literature on environmental issues presents there is, albeit at different level, a growing concern among all walks of life in modern societies (Dunlap et. al. 2000; Slimak &

Dietz 2006; Beyhun et al.2007; Gürsoy et. al. 2008; Altunoğlu & Atav, 2009; Sam et.al. 2010).

According to Baldassare & Katz (1992), environmental risk perception plays a critical role for developing and enhancing consciousness for environmental issues. Environmental risk, when broadly defined, is a culmination of dangers arising either in the form of human or natural disasters. Environmental risk perception, on the other hand, could be stated as people’s subjective judgments of these problems (Anantho, 2008). The literature on environmental risk perception has been seeking answers on such questions like, why do some people put high priority on some problems over others? or why does the environmental risk perception change from person to person? The literature also show that people from their opinions on environmental issues from different standpoints. Techno scientific approach views environmental risk perception as concrete, easily defined and observable, measurable phenomenon (Mark et.al. 2008). Psychometric approach, though it accepts techno scientific approach’s principles, considers other factors influencing risk perception (Slimak & Dietz; 2006). Comprehensive person of model includes such psychological factors as adaptability, emotional stability, psychomotor aspects of people in their analysis of risk perception (Chauvin et.al., 2007). Socio-economic, demographic and religious factors have great influence over risk perception. (Stern et.al.1999). Lastly, the trend called ‘risk society’ in 1990s puts risk at the heart of social and historical factors influencing social structure in modern societies (Yalçınkaya & Özsoy; 2003).

A multitude of measurement tools have been developed to study individuals’ and society’s environmental risk perception some of them, and their results are shown in table-1. Different samples of environmental risk perception surveys conducted show that people conceive of environmental risks at various levels. According to Sam et al. (2010) study of university students on environmental risk perception and environmental attitudes, university students appear to demonstrate high levels of environmental risk perception, and the perception of environmental risk and environmental attitudes they report signals strong positive relationship. Altunoğlu & Atav (2009) have found that, in their study on secondary school students' perceptions of environmental risk, secondary school students' environmental awareness on the environmental risk perception is higher than average. Similarly, Gursoy et al (2008) in their study on mid-level municipal employees, state that environmental risk perception is high, awareness of environmental issues is even higher. However, the levels of public risk perception and risk characteristics that determine the environmental risks in relation to the society needed to be trained by health professionals. However Beyhun et al (2007) study on the medical school classes, environmental risk is found to be perceived less urgent by the medical students. Meydan et al. (2009) in their study on student teachers claim that while teachers identify the global climate changes, global warming, air and water pollution, water waste of industrialization on the environment as a threat , perceive consumption habits and the luxury of life as a problem, but they do not adequate awareness and sensitivity on the greenhouse effect, acid rain, ozone depletion and erosion. Environmental risk perception for individuals who are sensitive to the problems of the environment is very important in creating or strengthening of these behaviors. It is known that that low attention to environmental problems, as well as the environment caused by the false perception of risk is very problematic.

The main purpose of this study, primary preservice teachers and science preservice teachers is also to determine the perceptions of environmental risk, perceptions of environmental risk education program, and whether they differ in a meaningful way in terms of gender.

METHOD

Participants

The study was conducted in the spring of 2009-2010 academic year at Siirt University in Turkey. Participants were 204 preservice teachers who were attending at primary and science education departments education departments in faculty of education.

Data Collection and Analysis

A descriptive survey research design was used in this study. As a means of data collection; personal information forms developed by the researcher and environmental risk perception scale which is developed Slimak and Dietz (2006) and adapted into Turkish language by Altunoğlu and Atav (2009) was used. This scale aims to measure the environmental risk perceptions of preservice teachers. Confidence in environmental risk perception scale, the Cronbach alpha reliability coefficient was 0.89, high points indicate how high is perception of environmental risk of preservice teacher. Factor analysis of this scale consists of 4 factors, accounting for 57% of the total variance. The first factor in factor distribution of substances, "*Ecological Risks*" (Cronbach's alpha = 0.82), the second factor "*Chemical Waste Risk*" (Cronbach's alpha = 0.79), the third factor, "*Extinction Risk of Resources*" (Cronbach's alpha = 0.81) and the fourth factor is the "*Global Environmental Risks*" (Cronbach's alpha = 0.69), respectively. Ecological risks consist of the following: loss of wetlands, invasive species, genetically modified agricultural products, forest sector, the construction of dams, chemical pollution of inland waters, eutrophication. The risk of chemical waste encompasses hazardous waste, radiation, heavy metals, persistent organic compounds, sewage, pesticides. Risks of resources are sport fishing, commercial fishing, overgrazing and population growth. The risks of global warming are in the acid rain, greenhouse effect, ozone layer depletion substances and oil extraction. In our study, Cronbach's alpha reliability coefficient, 0.79 for *ecological risks*, *the risks of chemical waste* for the 0.75, 0.78 for *the risk of depletion of resources* and to *global environmental risks*, 0.77, respectively. Cronbach's alpha reliability coefficient of 0.89 was determined to be the value in the scale.

RESULTS

Table-1. Means and standard deviations of primary and science preservice teachers' environmental risk perceptions scores

	N	Minimum	Maximum	$\bar{X}$	SS
Science preservice teachers	51	3.30	4.96	4.15	.40
Primary preservice teachers	153	2.17	5.00	4.16	.59
Total	204	2.17	5.00	4.16	.55

As shown in Table-1 mean scores of primary preservice teacher and science preservice teachers' environmental risk perceptions are high level.

Table-2. Primary and science preservice teachers' perceptions of environmental risk ranking of the distribution of points

Science preservice teachers' perception of environmental risk	Ranking	$\bar{X}$	SS	Primary preservice teachers' perception of environmental risk	Ranking	$\bar{X}$	SS
Hazardous waste areas	1	4.72	.53	Greenhouse effect	1	4.65	.68
Greenhouse effect	2	4.68	.58	Radiation	2	4.63	.72
Acid rain	3	4.66	.74	Acid rain	3	4.58	.74

Persistent toxic organic compounds	4	4.66	.51	Persistent toxic organic compounds	4	4.56	.77
Radiation	5	4.62	.52	Ozone layer hole	5	4.48	.82
Ozone layer hole	6	4.58	.53	areas of hazardous waste	6	4.55	.87
Sewage	7	4.58	.60	sewage	7	4.37	.94
Heavy metals	8	4.41	.72	Heavy metals	8	4.37	.86
Chemical pollution of inland waters	9	4.35	.84	Chemical pollution of inland waters	9	4.32	.87
Invasive species	10	4.33	.86	Euthrophication	10	4.26	.89
Degradation of habitats	11	4.31	.81	GMO	11	4.26	1.06
GMO	12	4.29	.94	Loss of wetlands	12	4.19	1.04
Oil drilling	13	4.25	.95	Oil drilling	13	4.08	1.03
Euthrophication	14	4.23	.73	Invasive species	14	4.17	1.00
Loss of wetlands	15	4.19	.87	Degradation of habitats	15	4.13	1.05
Pesticides	16	3.98	.96	Population growth	16	4.02	1.19
deforestation	17	3.96	1.14	deforestation	17	4.01	1.11
Dam construction	18	3.84	.92	Pesticides	18	3.97	.97
Population growth	19	3.78	1.13	Dam construction	19	3.75	1.23
Overgrazing	20	3.29	1.20	Overgrazing	20	3.75	1.13
Sports fishing	21	3.23	1.14	Sports fishing	21	3.54	1.25
Commercial fishing	22	2.94	1.13	Commercial fishing	22	3.30	1.36

According to table-2 science preservice teachers see, as the most important top five, environmental risks of hazardous waste, the greenhouse effect, acid rain, persistent toxic organic compounds and radiation, while the perceptions primary preservice teachers can be ranked like this: greenhouse effect, radiation, acid rain, persistent toxic organic waste and ozone layer depletion. It can be said that primary preservice teachers and science preservice teachers perceived as the most significant environmental risks in a similar pattern. Primary preservice teacher and science preservice teachers see the following less threatening environmental risks starting with the least important concern: commercial fishing, sport hunting and over-grazing were found.

Table-3. Means and standard deviations of preservice teachers' environmental risk perceptions subscale scores

Environmental risk perception subscales	**N**	$\overline{X}$	**SS**
Global environmental pollutions risks	204	4.47	.63
Chemical waste risks	204	4.43	.54
Ecological risks	205	4.18	.61
Exhaustion of resources risks	204	3.57	.95

According to Table-3, preservice teachers' perceptions of environmental risk as part of the subscales of global environmental risks, the highest mean scores can be attributed to (4.47), chemical waste risks (4.43), and ecological risks (4.18) and risks of depletion of resources

(3.57) According to this, perception and awareness of the risks of global environmental pollutions risks of preservice teacher are higher than chemical waste risk, ecological risks and exhaustion of resources.

Table-4. t-test results of preservice teachers' environmental risk perceptions subscale according to gender

Environmental risk perception	Gender	N	$\bar{X}$	SS	t	p
Global environmental pollution risks	Female	99	4.54	.56	1.59	.113*
	Male	105	4.40	.65		
Chemical waste risks	Female	99	4.45	.51	.612	.541*
	Male	105	4.41	.57		
Ecological risk	Female	99	4.26	.55	1.74	.082*
	Male	105	4.10	.69		
Exhaustion of resources risk	Female	99	3.64	.93	1.01	.310*
	Male	105	3.50	.97		

* p> 0,05

There is a no significant difference between the preservice teachers' global environmental pollution, chemical waste, ecological risk and resources exhaustion of environmental risk perceptions subscales when we consider gender as shown in table-4 (p>0.05). This means female preservice teachers' global environmental pollution, chemical waste, ecological risk and resources exhaustion of environmental risk perceptions subscales are higher than male ones.

Table-5. t-test results of preservice teachers' environmental risk perceptions subscale according to departments

Environmental risk perception	departments	N	X	S	t	p
Global environmental risks	Primary	153	4.45	.65	-.990	.323*
	Science	51	4.54	.46		
Chemical waste risks	Primary	153	4.41	.58	-.974	.321*
	Science	51	4.50	.36		
Ecological risks	Primary	153	4.16	.67	-.663	.508*
	Science	51	4.23	.48		
Exhaustion of resources	Primary	153	3.65	.96	2.23	.026**
	Science	51	3.31	.91		

*p> 0.05; **p< 0.05

In this study, the mean scores received from the environmental risk perceptions subscales were evaluated according to preservice teachers' departments. The preservice teachers' mean scores perceptions of global environmental pollution risks (t= -.990; p=.323), perceptions of chemical waste risk (t=-.974; p=.321), perceptions of ecological risk (t= -.663; p=.508) didn't different according to department.

As seen in Table-5, science preservice teachers' perceptions of global environmental risks, risks of chemical waste and ecological risk are higher than those of the primary preservice teachers. To see whether any significant difference based on these two programs, namely, primary preservice teacher and science teachers' perception of global environmental risks, the risks of chemical waste, ecological risks and risks of depletion of resources, according to the independent sample t-test result was analyzed. As a result, no significant difference between primary and science preservice teachers' perception of global environmental risks (t_{202} = -,990, p> 0.05), the risks of chemical waste (t_{202} = -,974, p> 0.05) and ecological risk perception (t_{202}= -,663, p> 0.05) was found, while there was a difference for perception of depletion of natural resources (t_{202} = 2.23, p <0.05).

CONCLUSION AND DISCUSSION

As a result, this study tries to find out how primary and science preservice teachers environmental risks perceive. Prospective teachers of primary and science environmental risk perception show almost the same level. Primary and science preservice teachers' perceptions of environmental risks reveal the following risks as the most urgent ones: the greenhouse effect, hazardous waste sites, acid rain, persistent organic waste compounds, radiation and ozone layer depletion. Similar studies like the one done by Beyhun et al (2007) shows that the medical students perceive as the most significant environmental risks: stress and the ozone layer hole. Gursoy et al (2008) in their study of municipal employees, municipal employees perceive the environmental risks most important ones as hole in the ozone layer, air, water and nutrient pollution, global warming. Altunoğlu and Atav (2009) the most important risks perceived by secondary school students are the greenhouse effect, radiation and the ozone layer hole. Slimak and Dietz (2006) study identifies as the most important areas hazardous waste, persistent toxic organic compounds, sewage, heavy metals, radiation. Walsh-Daneshmand and MacLachlan (2000) study indicates hole in the ozone layer, smoking cigarettes in public places, factory-derived pollution and radioactive pollution.

In our study, the risks of global environmental risks and ecological risks of chemical waste and the depletion of resources have been found to be prominent than other risk perceptions. Accordingly, preservice teachers' perception global environmental risks and ecological risks of chemical waste occupy a more prominent place than depletion of resources According to the study by Ozdemir and Constructive (2010), the preservice teacher who teaches geography and physics show more sensitivity toward soil pollution than science preservice teachers who do not teach those courses. In our country there is not quite number of work on preservice teachers' perceptions of environmental risk. However, similar studies on the vast majority of high school and college students show that students are not informed about or have incomplete and inaccurate information on global warming, population growth, depletion of the ozone layer preservice teachers will train the next generations, therefore the environmental risk perception is crucial in the development of effective behaviors. Not just a theoretical approach but project-based, problem-solving skills by applying such methods are more needed in the duration of their university education to be aware of environmental risks and their solutions.

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MAKING USE OF EDUCATIONAL RESEARCH IN THE PLANNING OF A NANOSCIENCE EXHIBITION

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Abstract: Although museums and science centres have an explicit educational role, educational research is generally not taken into account in a systematic manner when designing exhibitions. Rather, the development of those learning environments tends to rely on the know-how of the staff. A consistent procedure of carrying out and reviewing science education research would complement that expertise and support the educational role of science exhibitions. This paper therefore suggests such research-based approach by adapting the Model of Educational Reconstruction for the purpose of exhibition development following the idea of the Model for Personal Awareness of Science and Technology. The former model serves as a general framework to involve analytical and empirical research in the development of learning environments, while the latter model provides a specific view of visitors' learning in interaction with exhibits. The paper shows how these constructivist models can be interconnected in order to apply educational research for improving the long term learning profit of exhibition visits. The idea is illustrated with an example concerning research-based planning of a nanoscience exhibition.

Keywords: educational reconstruction, informal learning, nanoscience, science centre exhibition, personal awareness of science and technology

INTRODUCTION

During the past few decades, the educational value of informal learning environments has been increasingly recognized. As learning is regarded as a learner-led and lifelong process, settings such as museums and science centres play an important role in complementing formal education and in contributing to scientific and technological literacy (Bybee, 2001). Indeed, museums have undergone a big shift in terms of their role and justification in society (Hooper-Greenhill, 1992; B. Lord, 2001). They are now considered primarily as educational institutions. Exhibitions are the main mode of communication in museums and science centres, and thereby also the main way for executing the educational function of those institutions (Allen, 2004; Hooper-Greenhill, 1994; B. Lord, 2001). While the process of exhibition development usually relies on museum staff's and other designers' know-how (cf. Mortensen, 2010; Schauble & Bartlett, 1997), many scholars have pointed out the need for complementing that expertise and making exhibition development more research-based (e.g. Allen, 2004; Grewcock, 2001; G. Lord, 2001; Schauble & Bartlett, 1997).

The studies that may be useful in science exhibition development include not only museum research but also the fields of research on science education. Duit (2007) distinguishes the domains of science education research as follows: (1) Analysis of content structure; (2) Research on teaching and learning; (3) Development and evaluation of instruction / instructional design; and (4) Research on curricular issues and science education policies. This paper suggests how findings from all the domains of science education research, together with findings of museum research, can be used during the process of exhibition development in order to support the educational function of these environments. After suggesting a generic model, an example on research-based development of a nanoscience exhibition is given.

The suggestions here mostly concern the first phase of the exhibition planning process, i.e. the development phase (G. Lord, 2001, p. 4). The next steps of the exhibition project, phases of design and implementation, are chiefly beyond the scope of this paper. That is why e.g. the aspects of exhibit design and usability – that are crucial in terms of visitor's experience during the visit – are not addressed in the following. The paper does not suggest a complete model for exhibition engineering which is a far more complicated process including a variety of important considerations beyond the educational research findings.

THEORETICAL BACKGROUND

Literature on museum learning includes a multitude of studies that examine how the characteristics of an exhibit influence visitors' interactions, but as such they do not, however, provide a prescriptive model for how to exactly use that knowledge in exhibition development. Thereby, some suggestions for formalising the process have been made (G. Lord, 2001; Mortensen, 2010; Schauble & Bartlett, 1997). The present study complements these formalisations by suggesting how exhibition development may be informed by educational research in a systematic manner.

For this purpose, the study adapts one of the design-oriented research approaches, the *Model of Educational Reconstruction* (MER) (Duit, Komorek, & Wilbers, 1997; Duit, 2007), for use in exhibition development. MER is a methodological framework that combines analytical and empirical educational research with development of practical educational solutions. The fundamental idea of the model is that the content structure for instruction cannot be taken directly from science content structure, but has to be specially (re)constructed by paying attention to the educational goals as well as students' cognitive and affective perspectives. MER has three components that closely interact with each other: 1) Analysis of content structure; 2) Research on teaching & learning (including investigations on learners' perspectives) and 3) Development of learning environment (Duit, 2007).

Since the nature of learning in informal settings is different from formal education (see e.g. Allen, 2004), MER has to be specified with a view of learning in a science centre, i.e. an interpretation of visitors' interaction with exhibits and the aims of the visit, in order to be used in exhibition development. The approach suggested in this study uses the *Model for Personal Awareness of Science and Technology* (PAST) (Gilbert & Stocklmayer, 2001; Stocklmayer & Gilbert, 2002) to deliver such view. The model for PAST has a personal constructivist perspective that is in line with the modern views of museum learning, where audience is no longer seen as an undifferentiated mass, "the general public" (Hooper-Greenhill, 1992). According to the model for PAST, interaction with an exhibit can induce *an experience in a* visitor, whose *PAST* can thereby develop and move closer to the *target*, i.e. the scientific, technological or socio-scientific ideas represented in the exhibition. However, a fruitful experience necessarily has to arouse *remindings,* i.e. draw on visitor's prior experiences (Afonso & Gilbert, 2006). The model for PAST also emphasises that the educational significance of an exhibition visit arises in the long term, and should not be considered in terms of immediate learning outcomes.

SUGGESTION FOR A PROCEDURE FOR USING EDUCATIONAL RESEARCH IN EXHIBITION DEVELOPMENT

In the approach suggested in the study, the challenge of exhibition development becomes a challenge of creating appropriate *experiences*, related to some aspect of the *target*, that are likely to arouse *remindings* in visitors and interact fruitfully with visitors' *PAST*. Each of these elements can be considered in the light of research findings. Such procedure for employing educational research in the different phases of exhibition development is outlined in Figure 1. The procedure is developed on the foundation of the basic Model of Educational Reconstruction (Duit, 2007, p. 6) and to some extent resembles the earlier practical applications of it (e.g. Duit, Komorek, & Wilbers, 1997).

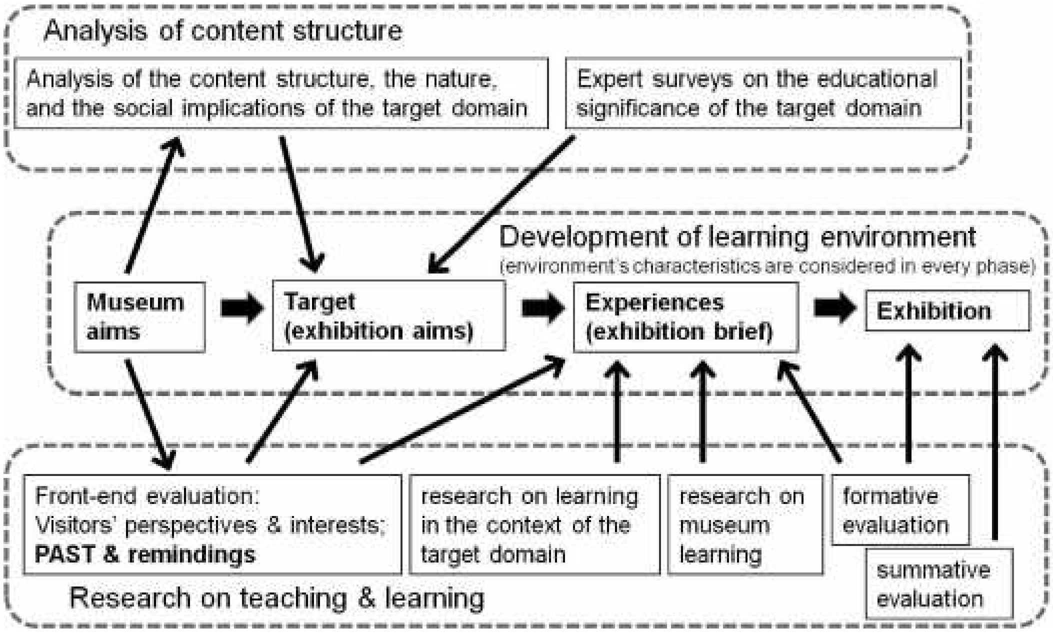

Figure 1. The suggested procedure for informing exhibition development through educational research.

The development phase of the exhibition planning process (G. Lord, 2001) can be roughly divided into four steps (Fig. 1): museum aims, exhibition aims, exhibition brief, and the actual exhibition (cf. Grewcock, 2001). Each of these steps can be informed with analytical and empirical studies carried out within the components 1 and 2 of MER. The *target* is defined on the basis of the general aims and characteristics of the museum, the analysis of content structure (drawing on literature on the nature and societal aspects of the content, and expert surveys) and the front-end evaluation of potential visitors' typical *PAST*s and *remindings* related to the *target*. The front-end evaluation also guides the development of the *exhibition brief*, describing the actual exhibits, by finding out fruitful contexts in which the *target* should be presented. Furthermore, this phase of exhibition development is supported by reviewing the literature on typical learning difficulties and conceptual challenges related to the *target*, as well as general literature on museum learning in order to find effective means of communication. After the exhibition brief the planning process continues to the design and implementation phases (G. Lord, 2001) during which the actual exhibition is created and evaluated. In the study, each of these ways for informing the exhibition development through research is discussed in detail in the context of the following example.

AN EXAMPLE: UTILISING RESEARCH FINDINGS IN THE DEVELOPMENT OF A NANOSCIENCE EXHIBITION

In order to illustrate the suggested approach, an example is provided on the use of educational research in the development of an exhibition on nanoscience. The example stems from a research project in the University of Helsinki, Finland, concerning nanoscience education. In the course of that research project an exhibition brief is being developed, hopefully to be later on implemented in a museum.

The process began by considering the general aims of the museum in question (see Fig. 1). On that basis, a tentative set of 'education for citizenship' -type aims were set for the nanoscience exhibition. They consisted of helping the visitors (1) to feel comfortable and competent with nanoscientific and nanotechnological matters and artefacts; (2) to follow the media discussion of the topics; and (3) to form informed opinions on social and ethical issues related to the fields. Such goals are broad enough to accommodate the visitors' personal needs, interests, and viewpoints in line with the idea of the model for PAST.

While contentual, curriculum-like learning goals do not fit an exhibition, the aforementioned aims must be broken down to a bit more specific aims in order to be usable in exhibition development. The planning team has to ponder what kind of knowledge of science and technology would, for instance, contribute to one's ability to make decisions on related issues. Such questions are constantly asked in science education research, and reviewing that literature can be used to choose content for informal settings as well. Hermeneutic-analytical studies on a specific field of science or technology, and analyses of its *educational significance* (Duit, 2007), can provide a good starting point for the exhibition development team. When laying the groundwork for the nanoscience exhibition, a review of the science and technology studies (STS) scrutinizing the field from philosophical and sociological viewpoints (e.g. Baird et al., 2004; Brune et al., 2006) was carried out (see Laherto, 2010). Furthermore, also empirical content-oriented studies may be used in defining the target of an exhibition (see Fig. 1). A growing number of expert surveys and Delphi studies have been published, analyzing the educational significance of many emerging fields of science and technology (for nanoscience, see Brune et al., 2006; Stevens, Sutherland & Krajcik, 2009). Also, surveys on science teachers may be useful since educators can be considered as experts in choosing content for science education. The nanoscience exhibition project applied some results of a survey on science teachers' views of the educational significance of nanoscale science (see Laherto, 2011a). All in all, the analysis of content structure for defining the target of the exhibition (Fig. 1) revealed not only the central scientific and technological ideas and concepts of nanoscience and nanotechnology (size-dependent properties, self-assembly, quantum effects, etc.), but also a number of educationally interesting features in the nature of these fields (interdisciplinarity, the 'technoscientific' character, distinctive roles of modeling and imaging), and in their interrelationships with society (potential benefits and risks), that are worth addressing in the exhibition.

Yet, at least equally important approach in defining the target of the exhibition is the front-end evaluation (Fig. 1). Visitors' perspectives are studied by reviewing pre-existing survey results or by conducting a new survey – preferably both of the ways should be used. The example project involved a review of polls and surveys on public's perceptions of nanoscience (see e.g. Crone, 2010). However, it is usually necessary to carry out a survey locally too, on the potential visitors of the museum in question. There are at least two alternative approaches. One is to survey a statistically meaningful sample of the whole target audience. Another approach is to conduct a small-sample interview or a focus group study in order to get a deeper insight (though not statistically significant) into the potential visitors' perspectives. In the nano-exhibition project, the latter approach was chosen. The results highlighted some fields of nanoscience and nanotechnology that the potential visitors may find especially interesting and relevant.

In the third phase, the *exhibition brief* (see Fig. 1), findings of that same visitor survey were utilized in order to find the typical misconceptions and learning difficulties which must be taken into account when designing the actual exhibits. The outcomes of the survey pointed out that, for instance, it is difficult to convey the correct epistemological ideas with the electron (or atomic force) microscope images widely used in nanoscience communication (Laherto, 2011b). The exhibition brief was also informed with a review of the educational research literature on teaching and learning of nanoscience. Several studies have, for example, shown that people of all ages have major problems in understanding the nanoscale (e.g. Castellini et al., 2007; Tretter, Jones, Andre, Negishi, & Minogue, 2006), but scale conception can be supported by teaching the continuum of scales, using relative comparisons instead of absolute sizes, providing size landmarks, and promoting proportional reasoning (Tretter, 2008). Such educational strategies were found to be appropriate for exhibitions too, and thereby such exhibits were included in the exhibition brief.

Furthermore, the procedure involved a review of research findings on museum learning (Fig. 1). While Brazilian exhibition *NanoAventura*, for example, solved the museographic challenge of displaying nano-objects in an exhibition by using computer games and virtual representations (Murriello, Contier & Knobel, 2006), the U.S. exhibition *It's a Nanoworld* employed concrete macroscopic models and analogies (Batt, Waldron, & Trautmann, 2004). For the exhibition brief, both types of exhibits were chosen. The literature review increased an understanding of the advantages and risks of different museographic approaches, thereby making it possible to use those approaches deliberately.

CONCLUSION

Hooper-Greenhill (1994) has argued that museums and science centres have failed in implementing their educational function. While this paper does not claim to provide a solution to this alleged problem, it does suggest how utilising findings from educational research in the development of science exhibitions might improve the educational potential of those learning environments. The paper proposes a generic model for museum professionals' use, and illustrates the model by providing an example on the development of a nanoscience exhibition. As the example discusses a research project instead of a typical exhibition project in a museum, it must be acknowledged that usually museums do not have much time and resources to engage in research during exhibition development. Even if the suggested model could not be used in its entirety, it still may be helpful in raising discussion on the need and the various possibilities of utilizing educational research in exhibition development.

As a personal constructivist model, PAST is line with the epistemological and learning-theoretical position of MER. Together they provide an approach for developing an exhibition with epistemological and learning-theoretical orientation that follows the lines of "the constructivist museum" suggested by Hein (1998, 155-179). MER provides a specification of different domains of literature and types of research that can be utilised in the process, whereas PAST specifies the purposes of those studies in terms of supporting visitors' *experiences* with the exhibits.

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THE CONTRIBUTIONS OF SYSTEMIC THOUGHT TO ENVIRONMENTAL AND HEALTH EDUCATION

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Abstract: The growing problems observed nowadays concerning sciences, technology, health and environment require far-reaching approaches that often need to transcend the teaching practices commonly adopted in formal education and that bring an effective contribution to scientific literacy. In this scenario, the present study addresses the contributions of systemic thought to the pedagogical practices that require the construction of links between different fields of knowledge, especially concerning Health and Environmental Education. As a whole, the results obtained show that the activities help pupils think over environmental issues due to the development of systemic though directed to the themes related to their communities. The results also show the importance of pedagogical practices that advocate the construction of contents as a wide network of themes whose directions make it necessary to utilize new approaches to the teaching of Sciences.

Keywords: Scientific literacy; Environmental education; Health education; Systemic thought, Elementary school.

INTRODUCTION

Finding efficient solutions for the problems observed in learning essentially requires the understanding of the dynamic of the interconnection between different classes of knowledge, especially the interdisciplinary aspects inherent to Environmental Education. For this reason, in order to include complex themes in elementary schools — like the use of agrochemicals, the consumerism observed in contemporary societies, alcoholism, and the outbreaks of epidemics like that of dengue — more comprehensive approaches that address several interconnected issues observed in the school community and its surrounding settings are required.

In this context, the present study analyzes the contributions of systemic thought to different approaches in the teaching of Sciences that include diversified pedagogical practices. With this in mind, the present paper reports the results of the investigations conducted with elementary school pupils on different relevant themes for contemporary education.

The debate between vitalists, who advocated the existence of a vital principle in living beings, and the mechanicists, was the fertile ground for theories called organismic and that hypothesized that organisms enjoy the ability to integrate their component parts and their functions. In this sense, Ludwig von Bertallanffy (1901 – 1972) aggregated the fundamental laws of chemistry and physics to philosophical questions, proposing a generalized version of the classical theory of thermodynamics that could be valid for closed systems as well as for open systems. Open systems were then used to explain the properties of living organisms as well as the processes that occur in systems formed by several animal and plant species, in the ecological relationships they have with one another. Due to the fact that open systems absorb energy, these systems are inclined to present negative entropy in a state of dynamic equilibrium that may lead to an increase in complexity (WECKOWICZ, 1989). Bertalanfyy (1975) defines system as a set of interrelated units.

In this perspective, when using systemic thought we are employing an approach that considers the whole without reducing it to its smaller parts. Therefore, the properties of the parts can only be understood based on the organization of the whole.

In this context, Morin describes systemic and complex thought as:

A key-thought, since it is built on the knowledge of the complex meaning of the word ‘system’. A system is not only formed by its parts; it has qualities, properties so-called emerging and that do not exist in each of its parts; in other words, the whole is larger than the sum of its parts. However, some qualities or properties of the parts are often likewise inhibited by the whole: thus it may also account for less than the sum of its parts.

In a scenario where the school is seen as a space of excellence for the diffusion of relevant knowledge, the discussion of themes about environmental issues includes the construction of interconnections between the different instances of knowledge that exist in society so as to establish prolific ways to the development of the community against the demands that continually emerge nowadays.

In this perspective, the environmental issue and the interfaces it has with health are examples of this complexity, especially considering the growing modifications that we observe in the environment built based on the growing presence of the human being in this context based on technology.

METHODOLOGY

This research was developed with a qualitative approach involving three different groups. The first one involved 10 7th grade pupils studying “consumer behavior”. The second one with 60 8th grade pupils studying the “dengue control” and the last one with 96 8th grade pupils discussing the “consumption of alcoholic beverages”.

This study had three stages:

- pretest – the preliminary data were collected obtaining the important subjects related to the used themes;

- practice activity – the main concepts were presented using dialogic explanation considering the knowledge of the students, discussing the interrelated between the different themes of the contemporaneity.

- posttest – additional data were obtained aiming to analyze the knowledge of students about the themes after dialogic explanations.

THE RESULTS

Based on the discussions about the dengue epidemic held with elementary school pupils (EINSFELD, 2009), the relevance of pedagogical practices that take into account the pupils’ previous knowledge gathered with the help of dengue control campaigns became apparent. Also, the need to implement actions in the community based on the effective role played by schools as protagonists of the diffusion of knowledge that add decisively to the fight against this disease was also observed, since the changes in the environment introduced by society represent one of the key aspects in the detection of outbreaks of the disease and in the establishment of prevention strategies.

In a study carried out on the theme “consumption” (PALÁCIOS, 2008), an approach was conducted that initially was associated to waste and garbage by pupils. Pupils demonstrated a relevant shift from essentially fragmented analyses towards a more systemic view of the themes analyzed, with allusions to environmental issues — more specifically to garbage — as well as the consequences of this aspect to the hydrological networks of cities. Additionally, direct references were made as to the impacts of the consumerism process to the health of citizens. This trend to broaden the spectrum of analyses and to conduct more in-depth reflections about the role of the human being in the environment represents the most important objective of the activity. This trend makes the actions developed in schools and directed to the promotion of citizenship and to the betterment of society more effective.

Another relevant theme is the consumption of alcoholic beverages, which demands specific actions in schools towards a better understanding of the ways to address the issue in a more effective way so as to alert pupils about the risks of alcoholism. The preliminary results afford to state that the theme was associated to there distinct spheres: (i) the consumption of alcoholic beverages in parties; (ii) the health problems associated (especially liver conditions); and (iii) the traffic accidents as a negative outcome of the consumption of alcoholic beverages. The answers revealed that youngsters have the hindsight of some relevant topics on the theme concerning health, and it was possible to observe that there is a need to enlarge the discussion on this theme so as do cover less commonly discussed consequences of alcohol to some systems of the organism as well as the social issues involved, aiming to promote debate. It was possible to observe, based on the activities carried out, that the youngsters were conscious of the risk of drinking, though this does not mean that such aspect changes their behaviors in everyday life. Therefore, it was revealed that this theme is very vast, and that is raises the curiosity of youngsters and that should be routinely addressed as important in scientific literacy. Also, the results confirm the advantages of systemic approaches that address the relationship between the different organism systems and, more broadly, the relationships between an individual’s values, habits of consumption and the consequences to the health system and the traffic and violence issues observed in our cities (DAL-FARRA, 2009).

Based on the development of pedagogical practices of this nature, the insertion of important contemporary themes based on systemic approaches affords the contextualization of themes without leaving behind fundamental conceptual aspects in the teaching of Sciences.

The quantitative results obtained were discussed on Dal-Farra et al. (2009), Einsfeld et al. (2009) and Palácios (2008).

FINAL CONSIDERATIONS

The activities conducted contribute to the pupils’ reflections about education, health and environment issues, due to the development of knowledge of thought directed to the themes related to the respective communities and global questions, and point to the importance of pedagogical practices that value the construction of contents on a systemic approach. The pupils´s reflections appointed to interrelationships between the themes, including environment, health and society in the context in which they live, connected with global issues relevant in contemporary contexts.

The results indicate also that teachers need to know the information transmitted in media about the themes of their disciplines to construct the strategies for teaching.

The studies conducted with elementary school pupils afforded to observe that acting based on a systemic approach to Environmental Education and Health Education affords to analyze and act more widely in terms of the possibilities to consider the insertion of the human being in this context. In this sense, the approaches conducted in the perspective of systemic thought contribute to the articulation of themes in different disciplines when we try to understand the multiple relationships, the randomness and the interdependence between the processes studied both in the context of Natural Sciences and in its interface with health issues and social aspects.

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LEARNING SCIENCE IN INTERACTION WITH THE EXHIBIT IN A MUSEUM OF NATURAL HISTORY

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Abstract: In this paper we present a study of science learning in a museum of natural history. We videotaped an educational activity where three teacher students study an exhibit with preserved animals, showing an eagle eating the carrion of a roe deer. There were also a pair of crows; one of them staying at a prudent distance from the eagle, whereas the other pinches the eagle's tail. Through a practical epistemologies analysis, we studied student's meaning making through the development of their discourse in encounter with the exhibit. The conversation generated by the activity is represented as sequence steps associated to six different themes. The theme concerning the behavior of the crows was one the themes where the students appeared to have gone furthest in the process of meaning making of the exhibit; they were able to provide a plausible explanation of the scene in terms of ecological relationships. In contrast, the theme concerning the carrion appeared to be considerably more difficult to make sense of; the students were able to fill several gaps concerning the identification of the carrion by distinguishing anatomical details; however, they could not fill the gaps concerning the absence of parts of the roe deer. The previous analysis of the conversation represents a description of learning from the point of view of the students; however it was possible to describe which aspects of the exhibit were noticed, what was easy to make meaning of and what remained unexplained.

Keywords: Museum, practical epistemologies, student teachers.

INTRODUCTION

For many years, museums have been known as environments that encourage informal learning experiences of individuals, families, and school children. In the field of museum education studies, an extensive research has been conducted with family visitors using a socio-cultural perspective (Leinhardt, Crowley & Knutson 2002). However sociocultural studies focusing on the relationship between informal learning, communication, and the purposes of the exhibit are unusual (Rennie, 2007). In this paper we present a discursive analysis of students' learning in encounters with an exhibit at a museum of natural history. The outcome of the analysis is then used to assess the relevance of the learning taking place, compared with the purpose of the exhibit.

Analysis of practical epistemologies

We used in this study an analysis of practical epistemologies. This method, which allows a description of meaning making in socially shared practices, has been used to analyze learning in school practices (Hamza & Wickman, 2008; Jakobson & Wickman, 2007; Lidar, Lundqvist, & Östman, 2006) and informal learning settings (Piqueras, Hamza & Edvall 2008). A practical epistemology analysis is an analysis of the actions taken by the participants of an activity as they engage in coping with what occurs in the situation. To analyze these actions on a discursive level, Wickman and Östman (2002) introduced four concepts: *encounter, gap, relation,* and *stand fast*. *Encounters* occur basically between persons and between persons and artifacts. As an activity proceeds, the participants notice *gaps* as a result of such encounters with other persons or artifacts. To fill a gap, new *relations* need to be established to what *stands fast*. Stand fast is defined as those words and utterances that are used by the interlocutors without questioning.

METHODS

The data presented in this study comes from a teaching activity of the educational program at the Museum of Natural History in Stockholm. The activity selected for our study utilizes a variety of exhibits with preserved animals in scenes that reproduce their natural environments. In small groups, and without the help of exhibition texts, the participants study the exhibits and try to make sense of different animals' behaviour, ecological processes, and biological interactions. The data presented here comes from three teacher students' encounter with an exhibit showing an eagle eating the carrion of a roe deer in a snowy landscape (Figure 1).

Figure 1. The exhibit

In the exhibit there are also a pair of crows, one of them staying at a prudent distance from the eagle whereas the other pinches the eagle's tail-feathers. The main purpose of the exhibit is to show the co-operating behavior of the crows to steal food from the eagle, but also to challenge the imagination of the visitors by placing details and clues in the scene (i.e. the missing head of the roe deer). The students' conversation was audio and videotaped and transcribed verbatim. The transcription was coded by marking *stand fast*, *encounters*, *gaps*, and *relations* in accordance with the analysis of practical epistemologies. After that, the conversation was divided into a series of steps, where the criteria for segmentation were the themes discussed during the conversation. Hence, a new step was initiated when the students began a new theme or switched from one theme to another.

RESULTS

The conversation generated in the encounter with the exhibit is presented here as a sequence of twelve chronological steps associated to six different themes (Figure 2). Here we present the initial part of first step and theme ("The behaviour of the crows"; Figure 2), showing how the practical epistemology analysis has been used throughout the conversation:

T: The crow…that he dares to pinch…at the tail's feathers.
E: Yes! Exactly!
E: That the crow dares to go so close!
T: Yes.
T: He [crow] is really pinching him [eagle]!
E: That was cocky!
T: Yes, indeed! Furthermore, I thought…It must be so that…They're carrion eaters!

E: Mm.
T: So they dare because they're surely starving.
E: Would he eat the crow?
T: I wonder about it ...They don't.
E: Well…it's not generally in the menu, but…
T: Well…I thought that…the little I know about vultures…
E: Yes…
T: There are no animals that eat vultures…They're at the bottom of the food chain, I think so…I'm not completely sure…I just believe so.

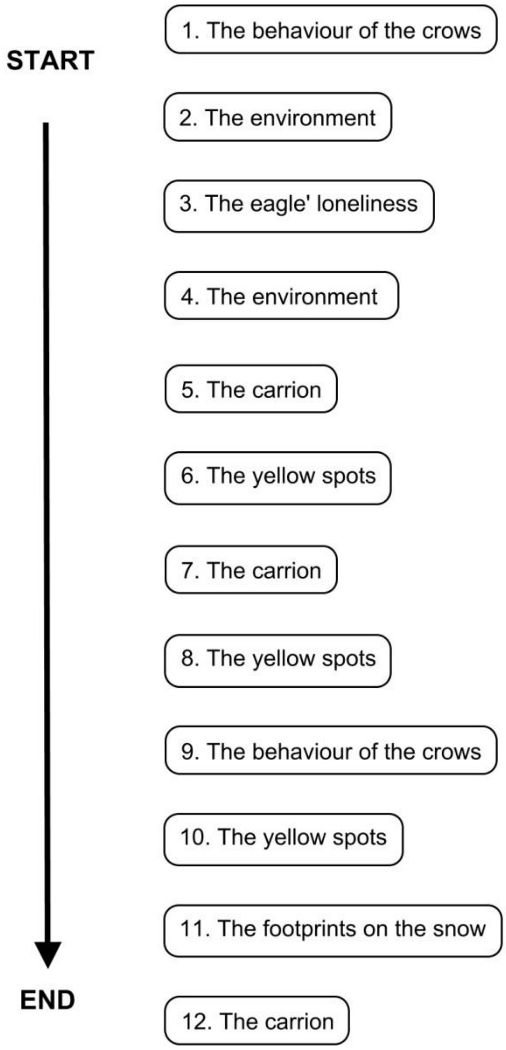

Figure 2. The path of the conversation represented as as a sequence of twelve chronological steps associated to six different themes.

Two gaps were noticed in this theme. The first gap concerned the behavior of the crows and especially how they could be so close to an apparently dangerous, much larger animal. The gap was filled with relations to the crows being carrion eaters and starving. The second gap concerned whether the crows could be a potential prey to the eagle. They filled this gap in a consequent way with the former relation about carrion eaters by establishing a relation to vultures and their foraging behavior. We may also note that several words stand fast to the students, that is, words that they used without questioning. These words, for example crow, vulture, starve, they, are used as starting points for establishing new relations to fill the noticed gaps.

The theme concerning the behavior of the crows (steps 1 and 9) was one the themes where the students appeared to have gone furthest in the process of meaning making of the exhibit; they were able to provide a plausible explanation of the scene in terms of ecological relationships between the birds. In contrast, the theme concerning the carrion appeared to be considerably more difficult to make sense of, that is, gaps lingered in several occasions. In the different steps where they talked about the carrion, the students noticed rather different gaps, focusing on the species (step 5), anatomical details and missing parts of the animal (step 7, 12).

Step 5:

T: Look at the animal [pointing out the carrion].

A: Ah…

T: I get curious…what kind of carrion is it?

E: I wonder…is it a lemm.. [lemming]?…what can it be?

T: Yes! I think so, it doesn't looks like an animal from the archipelago.

Step 7:

T: I wonder which part of the animal…if you think…
E: He [the eagle] has eaten the front part [of the carrion].
A: These are rib bones.
E: Mm.
A: There goes the oesophagus.
E: Exactly, some kind of throat.
T: He's eaten the whole head!

Step 12:

A: The question is if he [the eagle] can eat the head by himself.
T: No, that's right, the head's gone…and the legs! Where are they? I'm curious about what kind of animal it is.

The students were able to fill several gaps concerning the identification of the carrion by distinguishing anatomical details. However, they could not fill the gaps concerning the absence of the head and legs; these gaps lingered from step 7 and remained unfilled in step 12.

DISCUSSION

Analyzing students' conversation in this way makes it possible to view their learning as a journey, where the different themes represent alternatives path for the direction of the learning process. For this particular group of students, the six different themes represent those particular paths that they happened to explore in the encounter with the exhibit. The previous analysis of the conversation represents a description of learning from the point of view of the students. However it was also possible to describe which aspects of the exhibit were noticed, what was easy to make meaning of and what remained unexplained. We can conclude, that the students succeeded in finding an interpretation of the scene using a set of ecological explanation, but the carrion was a problematical part in the exhibit for the students. Similar analyses of other dioramas and activities can be performed, either by a researcher, a teacher, or a museum educator, for purposes of research, teaching, or, indeed, fine-tuning of museum exhibits.

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PRIMARY SCHOOLS TEACHERS' CONCEPTIONS OF ENVIRONMENT. A COMPARISON BETWEEN AUSTRALIA AND FRANCE.

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Abstract: Both Australia and France are similarly developed countries with comparable egalitarian societies but differ in some issues such as energy generation, agricultural and mining history, GMO cultivation, immigration. Both countries have implemented Education for a Sustainable Development (ESD) in their respective education systems. This paper explore primary teachers' conceptions of the environment, and how these relate to the broader national socio-scientific differences.

Using the questionnaire of the European research project Biohead-Citizen, we compared, by multivariate analyses, conceptions of 98 Australian and 272 French primary school teachers.

The Australian teachers' conceptions significantly differ from those of French teachers, mainly being more pro-GMO, more anthropocentric and believing more that some animals can feel happiness. The most anthropocentric and pro-GMO conceptions are correlated with more belief in God, practising religion, and trusting more in private than in public institutions, for schools, for health services and pensions. They also agree more with the propositions: *"It is for biological reasons that women more often than men take care of housekeeping"*, ***"****Ethnic groups are genetically different and that is why some are superior to others"* and ***"****There are too many foreigners in my country: the government should limit immigration"*.

Some hypotheses are proposed to interpret these differences, such as resistance to GMOs in France and Australia's immigration history. The greater endorsement in the Australian sample of values against equality between men and women, or among ethnic groups, is more difficult to explain, but may possibly relate to education or to characteristics of the local sociopolitical contexts.

Keywords: Education for Sustainable Development – Teachers – Environment – Values – Human rights –

INTRODUCTION

Australia and France differ in relation to some socio-scientific issues likely to be associated with differences in environmental and socio-political views. For example, Australia was the last country to ratify the Kyoto protocol, is the world's largest coal exporter, and in contrast to France generates no nuclear power. Both countries have a strong agricultural sector, with

Australia having rapidly cleared much of its native vegetation for agriculture and mining. Although GMO cultivation (of maize) has been banned in France, GM canola has just been introduced to cultivation in Australia. Australia has seen rapid large scale immigration since colonisation by Europeans only 223 years ago and currently 25% of the Australian population is foreign-born in comparison to 8.9% of the French population (OECD 2010). The gender gap in unpaid work is larger in Australia than France (Craig & Mullen 2010).

Education for Sustainable Development (ESD) is well implemented in the school curricula of the two countries. Australia has a very strong policy framework for ESD – although the extent to which this is implemented by schools is variable and arguably threatened by recent moves to national high-stakes literacy and numeracy testing. Environmental Education for Sustainability policy in Australia is also, on the face of it, more focused on values than in France (*http://www.curriculum.edu.au/values*). In France, Environmental Education has mainly been developed since the 90s, becoming in 2004 Environmental Education "to" and then "for" Sustainable Development, and ESD ("Education au Développement Durable") since 2007. In France as well as in Australia, the best examples of ESD are found in Primary Schools, where the same teacher can encompass all the dimensions of ESD, and there is more possibility of interdisciplinarity, and pedagogical innovations, than in the more tightly circumscribed secondary school systems.

RESEARCH QUESTIONS

In consequence, the present work aims to explore differences in Australian and French primary schools teachers' perceptions of nature, the environment and environmental education. Specifically we are investigating:

- their ethics and values relating to the utilization and/or preservation of the environment (Wiseman & Bogner 2003), corresponding to anthropocentric and / or ecocentric values;
- their opinions about genetically modified organisms (GMOs) and their use;
- their opinions about the ability of all animals to feel or not feel happiness;
- if the teachers' conceptions differ significantly according to variables such as gender, age, level of instruction, religion;
- whether there are correlations between the teachers' conceptions of environment and their socio-political and religious opinions, and their conceptions related to human rights and equality.

METHODS

We used the questionnaire constructed for the Biohead-Citizen research project (2004-2008), where most of the questions are focused on possible interactions between scientific knowledge and values (Clément & Carvalho, 2007). Examples of questions will be given below with the results. Each teacher filled out the questionnaire in a totally anonymous context. The sample comprises 98 in-service and pre-service primary school teachers in Australia (New South Wales), and 272 in France (Rhône-Alpes and Languedoc-Roussillon). The data were analysed by multivariate analyses (Munoz et *al.* 2009, with the free software "R" and the collaboration of the statistician Charline Laurent).

MAIN RESULTS

A PCA (Principal Components Analysis), as well as a Hierarchical Ascendant Classification, defines 4 categories of conceptions of environment:

1 – A pole more focused on utilization of resources, with an anthropocentric ethic, and more acceptance of GMOs.

2 – An opposite pole more focused on preservation of environment, with an ecocentric ethic, and more reticence against GMOs.

Inside these two poles, there are two groups of conceptions, which differ according to whether teachers think that animals such as frogs, snails or flies can feel happiness or not.

A Between Analysis, completed by a randomisation test (Monte-Carlo type), shows that Australian teachers' conceptions significantly differ from those of French teachers ($p<0.001$), mainly being more pro-GMO for the four questions related to GMO (e.g. A12 & A39: table 1), more anthropocentric (e.g. A32: table 1) and believing more that animals such as frogs and snails can feel happy (e.g., A29: table 1). A somewhat larger proportion of Australian than French teachers think that Environmental Education should be more focused on providing knowledge than developing responsible behaviour (17.3% *vs.* 5.5%).

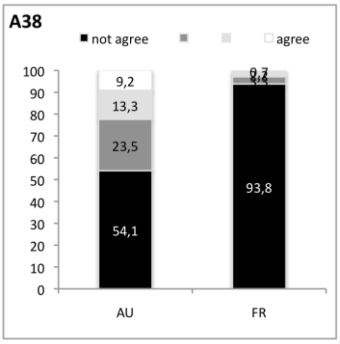
	Country	I don't agree			I agree
A12 – *"Genetically modified plants will help to reduce famine in the world".*	*Australia*	14.3%	27.6%	37.8%	20.4%
	France	36.4%	39%	20.6%	4%
A39 – "*Genetically modified plants are good for the environment because their cultivation will reduce the use of chemical pesticides (e.g. insecticides, herbicides)".*	*Australia*	16.3%	35.7%	35.7%	12.2%
	France	40.4%	39%	16.9%	3.7%
A32 – *"Humans have the right to change nature as they see fit".*	*Australia*	65.3%	22.4%	9.2%	3.1%
	France	91.2%	6.2%	1.5%	1.1%
A29 – *"Frogs are able to feel happiness".*	*Australia*	15.3%	29.6%	28.6%	26.5%
	France	39.3%	27.6%	22.1%	11%

Table 1 *- Answers of the 98 Australian teachers and 272 French teachers to some of the propositions of the questionnaire.*

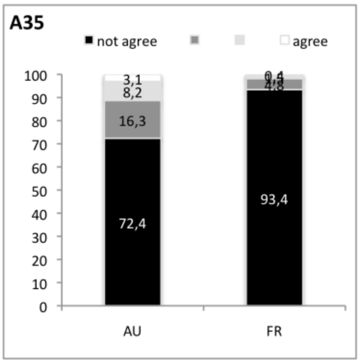
A Co-Inertia Analysis crossing the PCA from the variables Environment with a PCA from the socio-political and religious opinions shows that the most anthropocentric and pro-GMO conceptions are correlated with more believing in God, practising religion, and trusting more in private than in public institutions, for schools, for health services and pensions; and that these positions are more frequent in Australia than in France.

Another Co-Inertia Analysis crossing the PCA from the variables Environment with a PCA from the variables "human rights", shows a significant correlation: the teachers with the most anthropocentric and pro-GMO conceptions, also agree more often, for example, with the propositions A38 *("It is for biological reasons that women more often than men take care of housekeeping"*), A35 (*"Ethnic groups are genetically different and that is why some are superior to others"*) and A26 (*"There are too many foreigners in my country: the government should limit immigration"*): figure 1. That means that in Australia somewhat more teachers than in France wish to limit immigration (A26) and justify some inequality between men and women (A38) or between ethnic groups (A35) on biological grounds.

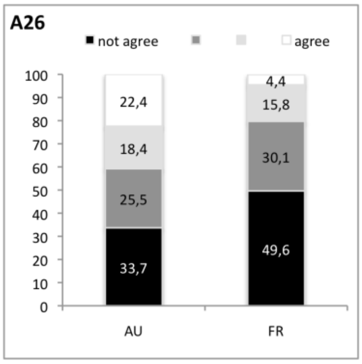
There are no significant differences among teachers' conceptions related to most of the other known parameters (gender, level of instruction, religion), except a little effect of age linked to the knowledge tested by item A49 – *"If a person eats genetically modified plants, his/her genes can be modified"*. The younger the teachers, (in both Australia and France) the more they disagree with this proposition.



A38 – "It is for biological reasons that women more often than men take care of housekeeping"



A35 – "Ethnic groups are genetically different and that is why some are superior to others"



A26 – "There are too many foreigners in my country: the government should limit immigration"

***Figure 1** - Answers of the 98 Australian teachers (AU) and of the 272 French teachers (FR) to the above propositions (in black: "I don't agree", in white: "I agree")*

DISCUSSION

Although the differences between Australian and French teachers are quite small, when compared to other countries in the world (see Clément & Caravita in this symposium, with the comparison between 24 countries), they are significant and raise several issues.

The finding that Australian primary teachers have significantly greater anthropocentric views with associated environmental utilisation ethic and acceptance of GMOs is likely to reflect broader national cultural differences outlined earlier in this paper, perhaps related to the relatively recent and lucrative history of utilisation of land for agriculture and mining in Australia. While GMOs are contentious in Australia, they are still being cultivated and there does not seem to have been the same widespread public opposition to the extent that has been experienced in France.

The Australian teachers' greater opposition to immigration may relate to the much higher proportion of immigrants in the Australian population and current concerns and media coverage about the arrival of 'illegal immigrants" and long standing fears of being "swamped by Asians".

More surprising is the greater number of conceptions in Australia justifying inequalities between men and women, and between ethnic groups on biological grounds. This raises the question whether this is a lack of biological knowledge, or also a justification of ideological positions on gender roles.

That fewer Australian than French teachers see Environmental Education as about developing responsible behaviour also signals a mismatch between the explicitly action-and behaviour-oriented EE policies in Australia and what is happening in Australian classrooms.

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FOOD AND NUTRITION IN BRAZILIAN SCHOOLS: HEALTH AND SCIENCE EDUCATION INTERACTIONS

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Abstract: The debate on healthy eating habits has been integrating many activities, inside and outside schools. The main professionals involved with this subject at schools are the science teachers, even though "health" is a transversal theme in Brazilian schools according to the National Curricular Parameters. The objective of the present study is to identify, within scientific publications, intersections between science education and health education in Brazilian schools amid the food and nutrition theme. In analyzing these papers, a focus upon teachers as the main knowledge transmitters was perceived, highlighting the necessity to enhance their knowledge on food and nutrition. It is important to signalize that teacher's contributions towards food and nutrition education in schools could involve a lot more. Teachers have the means to enrich the actual knowledge construction on this theme, to discuss the concepts of healthy eating habits, as well as the ways to analyze and understand their meanings and better forms of accepting them, or not. The presence of transdisciplinary views becomes fundamental especially when scientific concepts are involved. Nowadays it is not possible to talk about health whilst disregarding scientific knowledge and, on the other hand, science education constitutes an important field to be considered when health education activities are planned, especially at schools.

Keywords: food and nutrition education; science education; health education; transdisciplinarity; complexity.

INTRODUCTION

Presently, the debate on healthy eating habits has been integrating many activities, inside and outside schools. This demands efforts from different areas of knowledge and creates needs to deal with complex issues.

The Brazilian Ministry of Health has been working on the regulation of the food trade in schools with the objective of reducing the supply of unhealthy foods. Furthermore, there are recommendations from several governmental sectors concerning children's and teenager's eating habits with a focus upon the school environment. This concern can be observed within the proposals in the National Curriculum Parameters (PCNs) and the National School Feeding Programme (PNAE) from the Ministry of Education; the Ministry of Social Development and Fight against Hunger; the Food and Nutrition Security Policy and Health Promoting Schools from the Ministry of Health and the Interministerial Ordinance nº 1010/2006 a joint action from the Ministry of Health and of Education (Bezerra, 2009; Ribeiro & Caniné, 2007).

The National School Curriculum Parameters contribute to this issue by establishing health as a transversal theme that should be introduced in all subjects with different emphasis and in educational activities within the Brazilian schools. One of the objectives is that students start to value and adopt healthier eating habits as one of the basic aspects of well-being, and are able to act responsibly in relation to their own health and that of the community. This includes watchfulness over their eating habits. One of the great challenges for public schools, in this respect, is to create and maintain a connection between the PCNs and the National School Feeding Programme. Increasing attention has been drawn to PNAE because it is the most long-lasting and extensive enterprise in this context. It has also been undergoing changes in order to adopt educational actions and promote healthy eating habits with a transversal perspective in schools. The Health Promoting Schools initiative must be recognized for its understanding of health education with a holistic view and the suggestion of using participative methodologies for the creation of healthy environments and health service provisions. And finally, the Interministerial Ordinance nº 1.010/2006 establishes guidelines for the promotion of healthy eating habits within public and private schools and reinforces and extends the orientations of the PCNs. In this way, the complexity of the issue at hand is well acknowledged and suggestions for its incorporation within school curriculum have been made. The suggestions are based on integrating themes concerning eating habits in all of the study areas and providing day-to-day experiences in school, with a need for transversal propositions.

Changes in eating habits involve a complex phenomenon (Fischler, 1995) associating education with health sustenance, among other aspects. Thus, food and nutrition education require sectors and professionals from different areas of knowledge. This theme is a converging point between science education and health education, considering that it is an object of study in both areas. The former due to the understanding that science must be a part of general education so that all citizens may comprehend “the most general, positive and problematic implications” of what is defined as the “society of knowledge” and, in this case, its association with human being’s eating behavior (Schwartzman & Christophe, 2009). And in health education, because food and nutrition education fulfills what the World Health Organization proposed by dealing with “social factors that affect health, dealing with the ways in which different aspects of health and well-being are socially constructed”. Moreover, it includes “liberating pedagogical proposals, committed to the development of solidarity and citizenship, directing itself to actions with the purpose of improving the quality of life and of promoting mankind” (Schall & Struchiner, 2010). Although the possibilities for contributions in both fields of knowledge and the need for interdisciplinary and transversal approaches for the theme are recognized, this is not a reality within formal education. The introduction of food and nutrition education usually happens via science education due to its affinity to the curriculum and the teachers of this area. However, these teachers most commonly do not received training in the area of food and nutrition and therefore broach the theme superficially, giving out isolated information that falls short of the basic nutritional orientations (Souza, 2008). The same may occur with those who have the scientific knowledge within this theme, but have not been prepared to perform pedagogical interventions in schools.

In seeking elements that may expand this discussion, the objective of the present study is to identify, within scientific publications, intersections between science education and health education in Brazilian schools amid the food and nutrition theme.

METHODOLOGICAL PROCEDURES

A bibliographic survey was carried out in the *Scielo* database, within the title and the abstract fields, with the keywords “food and school”; “food and education”; “nutrition and school”; “nutrition and education”; “nutrition and science”; “food and science”. The search cumulated in 30, 40, 10, 28, 17 and 7 results for each keyword combination, respectively.

After a process of selection 12 papers published in Brazil, in the last 10 years (1999-2009), were included in this article. The selection criteria were articles related to food and nutrition themes within basic education.

RESULTS AND DISCUSSION

Were analyzed four papers related to topic of teachers training: Davanço *et al* (2004); Bizzo and Leder (2005), Schmitz *et al.* (2008) and Castro *et al* (2007). The other eight papers were analyzed in a previous study (Rangel & Fonseca, 2010).

The investigation carried out by Davanço *et al* (2004), aimed at evaluating the knowledge of teachers who had and those who had not been exposed to an educational programme. They considered that the exposed teachers were better prepared conceptually and were more aware of the roles of teachers and the school when it came to transforming reality.

Schmitz *et al.* (2008) also suggested a methodology for an educational programme to train preschool and elementary teachers and school cafeteria owners. They analyzed the participants knowledge on food and nutrition after and before the course. The conclusion was that the methodology helped expand knowledge amongst teachers and cafeteria owners, highlighting the school as a prime space for promoting healthy eating habits.

Broadening the focus to public polices, Bizzo and Leder (2005) proposed to include nutrition education programmes as a transversal themes in the National Curricular Parameters for Brazilian Elementary Schooling (PCN). These authors pointed out the necessity to adjust the nutrition undergraduate courses, to model and understand the construction and change in food habits within the school context, and to integrate this theme with other actions and interventions. These notes signalize an initial change in food and nutrition education views in schools, making it possible to think about an expansion of the concepts involved.

Finally, in the study developed by Castro *et al* (2007) there was an expressive participation of different school actors (elementary teachers, primary healthcare professionals, school cooks and adolescents) in testing an educational methodology for the promotion of healthy diets, adopting cooking as its structural axis. It was a theoretical and methodological innovation in the area, including concepts that had not yet been explored in this area, such as: “health promotion precepts, a critical approach to health education, the human right to adequate food, food and nutrition security and reflections about food culture in the contemporary context”.

Among these researches, eight papers were analyzed in a previous article (Rangel and Fonseca, 2010), indicating a relevant convergence between science education and health education. In these studies, it was possible to identify the transmission of scientific concepts as the main manner of conducting the health education interventions. It is important to highlight that most of these researches were carried out by health professionals, especially dieticians, and published in health journals. A similar conclusion was obtained by Silva and Fonseca (2009) that did not identify an explicit pedagogical intention in most of the food and nutrition education studies analyzed. When evident, the traditional theoretical and methodological views on education were predominant, with a main focus on knowledge transmission.

In understanding transdisciplinarity as a way to construct the unity of knowledge, considering the complexity (Nicolescu, 1999; Giotto, 2004), the need to interrelate knowledge in different research fields is strongly signalized, bringing to the discussions concerning food and nutrition some considerations from the area of science education. In order for this to become possible, the challenge to integrate health professionals and education professionals must be overcome. This challenge was also put in evidence by Boog (2009), who indicated this necessity as a means to enrich the Brazilian National School Feeding Program, which is managed by health professionals. Teachers do not recognize this program as an opportunity for pedagogical action because they do not participate in the decisions within it. Thus, the urge for investing in educational projects that involve a diversity of professionals is brought to the surface, in order for eating habits in school to become an possibility for learning and producing knowledge (Costa *et al*, 2001).

CONCLUSIONS AND IMPLICATIONS

In analyzing these papers, a focus upon teachers as the main knowledge transmitters was perceived, highlighting the necessity to enhance their knowledge on food and nutrition. It is important to signalize that the teachers' contributions towards food and nutrition education in schools could involve a lot more. Teachers have the means to enrich the actual knowledge construction on this theme, to discuss the concepts of healthy eating habits, as well as the ways to analyze and understand their meanings and better forms of accepting them, or not.

The presence of transdisciplinary views becomes fundamental especially when scientific concepts are involved. Nowadays it is not possible to talk about health whilst disregarding scientific knowledge and, on the other hand, science education constitutes an important field to be considered when health education activities are planned, especially at schools.

This way, socio-scientific issues could be one of the forms to integrate food and nutrition education with the knowledge enrolled in the different subjects at schools. It is a complex theme that involves concepts within the natural sciences, social and human sciences, environment and sustainable development, ethics, and many other areas of scientific and non scientific knowledge.

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ENVIRONMENTAL EDUCATION AND CLIMATE CHANGE: POSSIBILITIES OF LEARNING THROUGH A GAME

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INTRODUCTION

The Climate Change issue achieved projection in media and society, particularly after February 2007, with the publication of the forth Intergovernmental Panel Climate Change report containing predictions about the global warming issue, considering its causes mostly because of anthropogenic actions. The environmental education aims to forming critical citizens and that they participate individually or collectively of the problem solving in its social and environmental context.

Since elementary school, the content related to environmental issues should be discussed such as GCCs and their effects, searching for a comprehensive understanding of the social environmental issue and how it interferes in our daily routine, bringing the issue of climate changes to the classroom.

Since 1990 many countries have implemented investigations with the aim of collecting how the population in general or specific groups understand the climate changes and the related politics. Cartea (2008) coordinated the surveys of people's perception about the theme in Spain, having the following focus of analysis: the level of climate change identification as a problem; the valorization of its potential as a threaten; the deepness and scientific adjustment of information and the citizen's knowledge about climate changes; the sources of information access about the theme; the predisposition and the daily practices related to the reduction of greenhouse gases. It is also relevant to elicit the importance of knowing what the population in Brazil understands about this phenomenon considering they have been exposed to lots of media information.

To approach this polemical issue in the classroom and discuss these conflicts, we have built a game as an educational tool. The use of games in schools is one of the various resources to be used in discussion and understanding of contents in a more interactive way between students and teacher.

This work has as aims: to identify the elementary and high school students and teachers' conceptions regarding the theme; to produce material that would enable the pedagogical transpositions of the main scientific and social aspects related to the climate changes theme; to do workshop with the game in state schools searching for an integral view of the issue; identify the students learning aspects in relation to the theme after game interaction.

METHODOLOGY

To identify the representations related to the theme, we have developed an exploratory study through questionnaires, which aimed to identify if the person had already heard of the theme, where and the three first words that are associated with the expression climate global changes. The data collect tool was applied with 52 teachers of state schools and with 259 students of a state school of Santo André city, São Paulo, Brazil. From those data and theoretical references, the main conceptual contents were thought to be incorporated in the pedagogical material produced and in the proposals of discussions to be created from it.

The game was used in a state school workshop in November 2010, with 29 high school students in an average group of 4 people. After finishing the game we applied a questionnaire per group, searching for the identification of perceptions about the theme after the interactions presented by the game.

Evaluation of the target audience perception and production of the game

According to the survey all teachers had already heard of the theme and 31 students did not know anything about it. The teachers have as main source of information about the theme the television, the newspaper and the radio. The students have pointed out television, followed by the school and then newspapers and the Internet. Cartea data (2008) have also confirmed the use of media to spread information and masse access to technologies of information in great scale. In table 1, it is possible to evaluate the main representations about climate change of state school teachers and elementary/high school students:

Table 1 - Main representations about climate change of state school teachers and elementary/high school students

Associated words	**State school teachers**	**Elementary and high school students**
Global warming	-	78
Pollution	9	72
Heat	2	48
Melting/ Glaciers	10	26
Rain/ Flooding	6	46
Deforestation	5	44
Catastrophes/chaos /death	12	6
Greenhouse Effect	3	35
Cold	-	24
Action/habits/attitudes	20	1
Man /Anthropogenic	3	7
Ozone layer	8	2
Natural resources	2	13
Air / Atmosphere	-	12
Species extinctions	1	4
Snow/ Snow storm	-	10
Disasters /suffering	-	10
Burnings	2	7
Consumption	2	-
Protection/prevention/ sustentability	7	1
Garbage/ recycling	2	5
Carbonic gas/carbon dioxide	2	2
Education	4	2
Others	24	68

From data exposed in the previous table, it was possible to observe that this public has various interpretations of the phenomenon. Besides the information expressed in the figure, many other words were quoted only or two once and grouped in as “others”. It is pointed out that important aspects associated to the causes were quoted only a couple of times such as carbon dioxide, burnings and consumption. These superficial perceptions were also identified by Cartea (2008), indicating that the understanding has scientific and social politics gaps, thus not establishing a clear relation between the identified problem and the individual and collective responsibilities. The wrong relation with other environmental problems, such as ozone layer has also been showed by Rye *et al.* (1997) and Leandrini & Motokane (2009). Rye *et al.* (1997) emphasizes the need for instructional materials that help students differentiate which are the environmental problems.

It is observed that, in a general way, the words chosen by students express more numerously the consequences brought by climate changes than the causes, what has indicated us how important is to deepen the issues linked to the causes in the game. With those results and after theoretical deepening of the theme, the first prototype of an interdisciplinary pedagogical game on environmental education was developed for elementary and high school students, considering the following objectives: to handle situations and environmental issues related to global climate changes in a playful way; to relate the phenomenon with the daily routine of people and with different school contents; to offer possibilities of dialog before and after the game to work with the construction of consistent argumentations to position face to environmental issues; to develop skills to take actions of group participation in environmental problems, considering the regional particularities.

Having it in mind, a game of strategy was created using 20 cards with attributes of attack (causes, consequences and vulnerabilities) and 20 defensive (adaptation and mitigation) where each card has a meaning about climate changes besides 8 scenario cards representing regional Brazilian particularities. During the game, students looked for strategies to minimize the effects of global climate change in different scenarios.

In the workshop, students participated actively during the game and pointed out the following words as main ones: Greenhouse Effect, Pollution, Preservation, Biodiversity, Environmental Damage, Humanity, Burning, Recycling and Drought. The main actions students judged as minimizing factors of climate changes were: Preservation, Renewable development, Water preservation, Recycling, Biodiversity protection, Awareness, Environmental education, Planting and Replanting, Ecosystem protection, Forest recovering. We noted that more relevant new words were then learned.

CONCLUSIONS

After the game an oriented debate was mediated by the teacher who commented on and discussed with students the cause and mitigation of climate changes making a relation to what they saw in the cards and in the dynamic of the game. This was only the first workshop and others have been already planned to happen with the use of the material, from where we will bring more data to be analyzed. The material was designed to contribute with the inclusion of scientific knowledge about the theme, thus agreeing with Jiménez-Alexandre & Pereiro-Munoz (2002) that the use of conceptual knowledge, besides valuable it is necessary to understand the environmental issue, evaluating the possibilities for problem solution. The spreading of scientific knowledge and social and cultural order should reach the society and one of the ways is the environmental education through interactive materials that challenge the thinking and propose an investigative, participative and critical attitude.

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TALKING SCIENCE: THE POPULAR ASTRONOMY OF CAMILLE FLAMMARION

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Abstract: In scientific practice, there is no image by image. The image is still regarded as a process, the result of a theory or reasoning or a model representation. This article will introduce the discussion on the functioning of images in a popularization science work. We analyze the fifth edition the "Astronomy Popular" of Camille Flammarion. In this study we have taken the discourse functioning concepts proposed by Michel Foucault to analyze one semiotic system. In conclusion the study indicates a functioning of illustration and a demonstration of the evidence "do science" in this work.

Keywords: Camille Flammarion, the popularization of science, the discourse functioning, popular astronomy.

INTRODUCTION

Image in science is an association among a technical process, a referent, a phenomenon or an object that one wants to observe or represent, as well as a scientific model. Without these associations, an image in science is just a visual element, a characteristic which marks the memory. It may be a summary of an equation, a mathematical or physical concept or even the creation of lines and colors of a mathematical model. According to Sicard (1997), these images have two iconic paradigms: the first, similar to photographic, a tool captures a fraction of real object, while the second captures a diagram of operation, punctuates what must be seen. The images in scientific research apparently belong to the second paradigm, nonetheless the science popularization should be working more with the first one. It is this assumption which directs our work to investigate the functioning of the images included in a science popularization text.

The images in sciences to Latour (1997) are often "technical images", the result of an "regard orchestrated" by artifacts or theories. The image capture, however, is not enough for science. Robert Hooke and Antonie van Leeuwenhoek, through the microscope which was built in the seventeenth century, observed the plant cells. Only a century later, the cell theory could give a meaning to this observation.

Astronomy has a pioneering role in the development of images in sciences. The introduction of the telescope, according to Bennett (2007), has transformed the instruments of astronomical observation in the seventeenth-century. Until 1609, before the construction of the astronomical telescope of Galilee, astronomers with only the power of their eyes and looking at a small fraction of the electromagnetic spectrum started the adventure of sciences with the image in meticulous drawings which were the instruments of their arguments.

The images produced by science have become more and more complex in the extent that technology has the interaction with possible differentiated levels of energy in production. The new instruments: an electron microscope, a positron camera or a system of satellite-tracking, on the other hand, have lost the dialog with the human dimension. In this context, I will discuss, in seeking to query its pragmatic functioning within science popularization discourse, all contained in the 1955 Nicolas Camille Flammarion fifth edition of "Popular Astronomy”.

THE IMAGE IN DIALOG WITH A TEXT

When we talk about images inserted in sciences text, two natures emerge. The first nature of the image is the reflection on a mirrored surface, and the second nature of the illustration is the representation pictorial, which indicates what seems to be seen. I will consider Michel Foucault’s definition (2000) of discursive procedures group which coordinates the discourse order. Such works differentiate the penetration of subjects in the discourse products. The image is an important element in all languages: natural, mathematics, iconic, graphics among other things and, it may be considered a component of a communicational act where social actors build and share a universe of meaning.

To consume the communication act, the interlocutors are legitimate as communicating subjects who share intentions, purposes, intersubjectivites and ways of expression adjusted to the communicative situation (Nascimento, 2007).

In the study that we propose in this article, we analyze a general public book, which we can characterize as a science popularization work. The studies on science popularization texts, developed by Daniel Jacobi (1998), indicate a dynamic of writing around the concepts and the scientific terms which are employed for the circulation of scientific knowledge outside from their production and validation sphere.

THE POPULAR ASTRONOMY OF CAMILLE FLAMMARION

For Carle and Guédon (1988), science popularization, non-formal or informal education composed by a nomenclature, is still subject of controversy, but these authors suppose that we are talking about the promotion of public access to knowledge and to scientific and technological information by means of mechanisms of differentiated schooling. The astronomer Nicolas Camille Flammarion (1842-1924) has devoted his life to the disclosure of astronomical research. Its main publication, "Popular Astronomy", was published in 1879. His work includes books, directories and journal articles and, in 1882, he founded the Popular Astronomy magazine, a monthly bulletin which were broadly disseminated.

For Jeanneret (1994), Flammarion participates in a "extension program" committed "to say the reality" by proposing moving away from a theoretical discourse which characterizes the scientific language. Popular Astronomy presents very rich and some colored pages and it is a continuous text, cut by chapters with attractive titles, for example, the Earth in the sky. Eventually, the title is accompanied by a brief indication of the covered subjects: how Earth turns on itself and around the Sun... Each illustration has a title, which sometimes, is reported in the text. Before it, there is a text to read in its entirety, similar to other texts about the disclosure of time (JEANNERET, 1994: 256).

In all the six books, as well as on the astronomy´s instruments annex directed to amateurs astronomers, we find 819 images numbered, two celestial charts, tables with astronomical data and an index. Most of these images (607 out of 819) are photographs with illustrative function surrounded by Jacobi´s framework. There are also celestial and land charts (28), systems of graphs (155 tables, graphs and diagrams) and schemes (29). The presentation of each book is almost always preceded by a colorful image, being all the other photographs in black and white. The intention of the popularization without trivializing science is reached from restatements of scientific discourse considering the first discourse. The science popularization discourse, with the restatements which are characteristics, is well marked, for example, by the complete explanation of elements which make up the project.

> Camille Flammarion aimait dire qu'il faut vulgariser la science sans la rendre vulgaire. Telle est la formule qu'il a appliquée dans cette Astronomie Populaire, dont le succès immense a contribué à répandre les connaissances astronomiques et a suscité de nombreuses vocation d'astronomes.Mais cet ouvrage irremplaçable exigeait aujourd'hui une refonte complète: sans en altérer le plan, il convenait d'y introduire les étonnates découvertes de la science contemporaine, et notamment un tableau de l'univers sidéral d'une telle ampleur que l'imagination bardie de Flammarion lui-même n'arait jamais osé le concevoir. Heureusement, l'éducation scientifique du public actuel l'a préparé à recevoir l'enseignement direct des faits et à goûter la poésie des spectacles grandioses qu'un abondante illustration photographique met ici sous ses yeux. (1955:p.3 griffin our)

In this book, the discourse, in general, is restated by the explanation in different languages, for example, the photography below 351 (p.249) which illustrates the nuclear reactions represents a descriptive form (1 Carbone^{12} + Proton = Azote^{13} + Energy) and an explanatory text.

IMPLICATIONS FOR THE SCIENCE POPULARIZATION

The images can be thought, in the case of Flammarion's science popularization work, in a dynamic among instruments, real object and its representation. This "real object" is an ideal shared by the French popular education program, by the time it approached sciences speech and scientific education, movement which still been observed in the 20th century, in the constitution of scientific culture associations (NASCIMENTO, 1999). The use of photographic images can be interpreted as this "explanation of real".

The interest on the image in this work can be attributed to its evidence value. The development of photography, in the 19th century beyond being an element of proof, in the science popularization discourse brings the traces of the object observed involved by delight and emotion. There is in this edition, also an attention to show images of scientists in pictures, paintings, engravings, and in scenes of using instruments. The illustration functioning favors the sensational aerial photo images, as well as inaccessible spaces: polar landscapes, Earth or global images, images of the limits of the universe, among others. These works still can be observed today, in the election science popularization images in this science area. A relationship ever investigates how these images can be found in other sciences writing traditions, and in the science teaching. In this study, however, we introduce this theme for the discussion toward opening other possibilities for future analyzes.

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URBAN AND RURAL PRIMARY SCHOOL PUPIL'S CONCEPTIONS ABOUT THE RESPIRATORY SYSTEM AND SMOKING

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Abstrat: An important objective of primary school teaching is to make children learn scientific contents and for this teachers must know their pupils' previous ideas in order to provoke effective conceptual changes. We analysed primary school pupils' conceptions and their learning difficulties by carrying out a cross-sectional study. Conceptions of respiration and smoking of young pupils (5/6 to 8/9 year old) were analysed before the first formal teaching of the topic and we followed their conceptual change immediately after teaching and one year after. We focused on the anatomo-physiology of the respiratory tract as well as on the unhealthy effects of smoking. The aim was to identify not only patterns of children's previous ideas about breathing and smoking unhealthy effects but also epistemological and didactical obstacles to learning.
Several patterns on the passage of tobacco in the smoker's body were created from children before teaching. Significant differences ($p<0.05$) between urban and rural schools as well as between year sub-samples of either urban or rural schools were found. After formal teaching, about 90% of 3rd and 4th year pupils represented the correct anatomo-physiology of the respiratory tract ($p<0.05$). However no significant differences regarding smoking effects were found ($p>0.05$). The use of these patterns of children's previous ideas about breathing and smoking may be relevant for teachers to use them in the process of pupils' conceptual change.

Keywords: Primary school, Respiratory System, Smoking, Urban and rural pupils.

INTRODUCTION

Children coming to primary school have their own conceptions that have been built from their daily life and some personal learning from parents' education, children's books, TV and other media. An important objective of primary school teaching is to make children learn scientific contents and for this teachers must know their pupils' previous ideas in order to provoke effective conceptual changes (Driver *et al.*, 1989; Pozo & Crespo, 1998; Canavarro, 1999; Giordan, 1999; De Vecchi & Giordan, 2002). Two types of pupils' learning obstacles have been identified: (i) epistemological obstacles, related to children's conceptions gained from their everyday life, and (ii) didactical obstacles, related to inadequate formal teaching (Clément 1994, 2003). Previous reports have described pupils' conceptions on digestion from their drawings (Carey 1985, Turner 1997, Giordan, 1999, Teixeira 2000, Psarros and Stavridou 2001, De Vecchi & Giordan, 2002, Reiss *et al*. 2002, Author, 2004) but on the respiratory system little has been investigated. In the present study we analysed primary school pupils' conceptions and their learning difficulties by carrying out a cross-sectional study. Conceptions of respiration and smoking of young pupils (5/6 to 8/9 year old) were analysed before the first formal teaching of the topic and we followed their conceptual change immediately after teaching and one year after. We focused on the anatomo-physiology of the respiratory tract as well as on the unhealthy effects of smoking. The aim was to identify not only patterns of children's previous ideas about breathing and smoking unhealthy effects but also epistemological and didactical obstacles to learning.

METHODOLOGY

In this study the data collection instruments included a questionnaire, which consists of an iconic part and a text. In this collection, we applied the technique of expression in the form of design because the children, in this age group, express better their ideas and their knowledge through the iconic representation (Giordan e de Vecchi, 1988). The design avoids the embarrassment of the child and the design is an alternative way for students who have difficulty expressing their ideas verbally (Rennies e Jarvis, 1995). The use of drawings is a technique that identifies the students' conceptions.
This is a transversal study applied to pupils of the four earlier school years of primary school (5/6 up to 8/9 years old). The teaching of the respiratory tract (and the others human systems) occurs at the 3rd year in the Portuguese curriculum. The schools were from urban and rural areas of Braga District, 191 and 201 children, respectively. We applied a short questionnaire, interviewed the children, and also analysed their textbooks. Children from the 3rd year were questioned one week after the teaching. They had to answer to the questions by making drawings as well as writing captions and any notes they thought could explain their drawings. Younger children of the first and second school year (5-7 years old) were helped by the researcher in the writing.

The questionnaire was composed of 5 simple questions:

i) Draw where the breathing air goes in your body.
ii) Look at your drawing and explain where the air goes in your body.
iii) Draw where the tobacco goes in the body of a smoker.
iv) Look at your drawing and explain where the tobacco goes in the smoker's body
v) What are the tobacco effects?

Categories were created from the children's drawings and writings (Marshall & Rossman, 1999; Bardin, 2000). Each drawing and writing was then allocated to a given category and data were treated by using the Qui-square method at the significance of 95%. The Statistical Package for the Social Sciences (SPSS) program was used.

RESULTS AND DISCUSSION

Several *drawing categories* about the passage of tobacco in the smoker's body (**question *i***) were created out of the drawing of 1st and 2nd year children, before teaching (Fig.1). A larger variety of drawing categories could be found in urban (Fig. 2a) than in rural (Fig. 2b) schools. Some 1st and 2nd year pupils drew only one lung ("L1") or two lungs ("L2", Fig.1a) with no connecting tube; one or two lungs with a single tube ("L1t/L2t", Fig.1b) and there were cases of two lungs with two tubes in parallel ("L2L", Fig.1c). The correct representation of two lungs with two tubes joining a single tube (L2T) (often darkened, highlighting the tobacco injury, "L2Td", Fig.1d) were also present in a proportion around 20% before teaching, in both urban and rural schools (Fig.2).

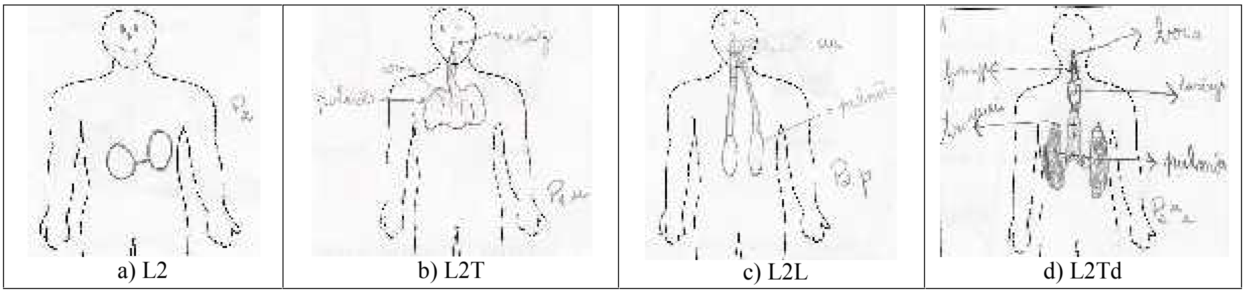

Figure 1: Examples of drawings of four categories found in pupils' drawings before (a to c) and after (d) teaching.

After the formal education the category "Lungs" increases in the 3rd year to 92% and there is a regression in this category, the following year (83%) in favour of other minor responses, namely the category "not known" where 13% of the students proved difficult to explain and name the organs through which the tobacco smoke, confounding them with organs of other biological systems. We can then infer that after a year of these learning, students in fourth grade did not retain concepts and knowledge about the category "Lungs".

Significant differences ($p<0.05$) between urban and rural schools as well as between year sub-samples of either urban or rural schools were found (Fig.2). After formal teaching, about 90% of 3rd and 4th year pupils represented two lungs with two tubes joining a single tube ("L2T"), where above 20% of urban (Fig.2a) and above 10% of rural (Fig.2b) pupils darkened the lungs, "L2Td", highlighting the smoking harm. The formal teaching in this case is clearly evident, which is confirmed by statistical analysis, $p<0.05$.

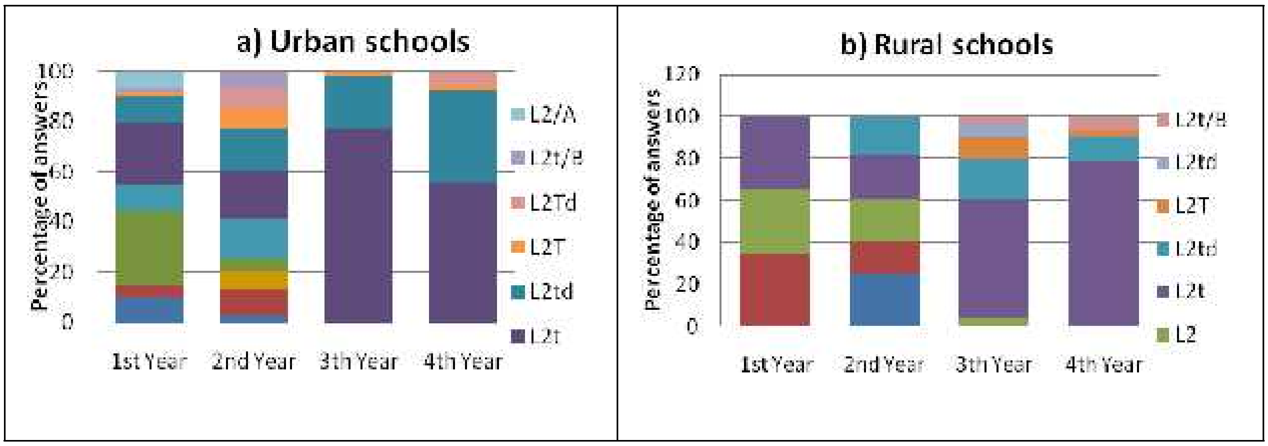

Figure 2: Categories frequencies on the tobacco passage through the body in urban (a) and rural (b) schools.
P<0.05 between urban and rural samples, and between sub-samples of urban and rural samples.

The *writing categories* "Disease/Lungs" and "Disease/Death" concerning tobacco smoking (**question *v***) were the most frequent ones in both urban and rural children (Fig. 3). No significant differences were found among samples ($p>0.05$): neither between urban and rural samples nor between year sub-samples within each urban and rural sample. These results show the breathe teaching at year 3 caused no significant effects on children's conceptions regarding the effects of smoking. However the category "Disease/Lungs" tend to decrease from the 1st to the 4th year in the urban school (Fig 3a) in contrast to the rural schools which tended to increase slightly (Fig.3b), though this being not significant at the level of 95%.

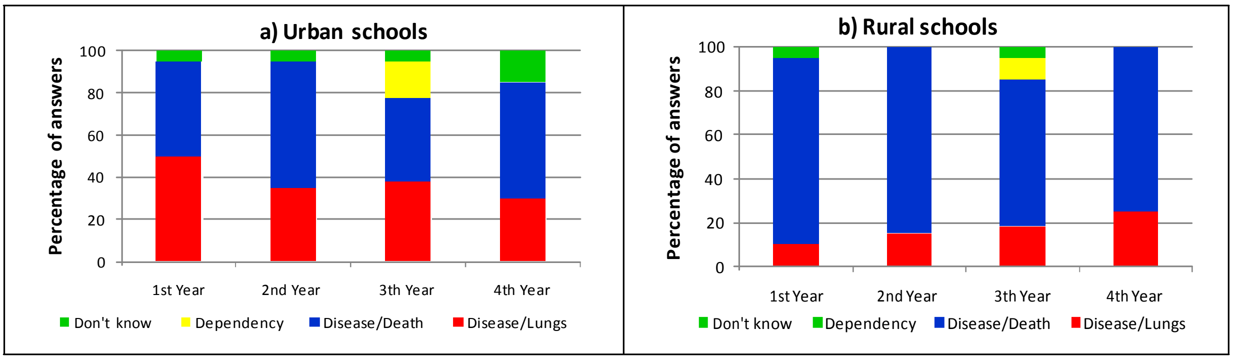

Figure 3: Categories frequencies on the tobacco effects in urban (a) and rural (b) schools.
P>0.05 between urban and rural samples, and between sub-samples of urban and rural samples.

It is interesting to note that in Urban Schools (Fig. 3a), before the formal education and more specifically in the 1st year the category "Lung Diseases" predominates with higher percentages (50%), contrary to the 2nd year that highlights the first option in the category "Diseases / Death" (60%), associating death to several diseases caused by tobacco smoke, followed by the category "Lung Diseases" with 34%. These children, in the process of informal learning, are aware that tobacco smoke has adverse effects in some organs of the human body. For them, this substance is very harmful to health and particularly to the lungs because they are darkened, the smokers have more difficulty breathing, and also because it causes various types of diseases in certain organs, including lungs, including some lung cancer. Analysing the results from the two areas (Urban and Rural) we notice that in the 3rd year the children have also revealed more formal knowledge about the dangers of tobacco, to discover that a small percentage of students (16%), refer to the category "Addiction" as one of the main effects caused by tobacco smoke in humans.
In the category "Disease/Death" children allude to death and various diseases or injured organs caused by tobacco smoking (cancer, cough, cholesterol as well as throat, stomach, breast, liver and heart illnesses). Interestingly is the fact that smoke addiction is only referred by the 3rd year pupils (1 week after teaching) from either urban or rural areas. However, as mentioned before, this was not found to be statistically significant (p>0.05).

In the iconic representation of the respiratory system there is, before the formal education, the presence of very simple concepts on the respiratory process, being almost always present the main body of this unit (lungs) or the presence of other organs that do not directly relate to breathing (Heart, stomach, intestines ...) and that, although out of context seem to be relevant for these children. By drawing schematically the child represents what he knows and what he feels through similar situations with their reality. After the formal learning, there is very significant development with regard to the anatomy and physiology of the respiratory tract, in the sense that certain simple representations gave way to more complete and scientific conceptions. In fact, in this age group, the similarity of real objects, (Lowenfeld, 1977), represent what we actually observe, learn and think (Mèridieu, 1974). Associated with this conceptual evolution in relation to the iconic representation of the anatomy of the respiratory system, there is still the presence of conceptual ideas a bit incomplete in terms of scientific.

The diagrams are produced to the lungs and from here there is no continuity of the rest of the process, relating to respiratory function. We can thus infer that the children in their answers "break" the continuity of the respiratory system, neglecting the interrelationship between the respiratory and circulatory.
So we may say that the patterns of children's previous ideas can be created (like in Fig.1) and that teaching was particularly effective in children's conceptual change regarding the respiratory tract (like in Fig. 2) but not relevant in healthy issues (Fig. 1), suggesting that teaching was not addressed to healthy, just like the pupils' textbooks. The use of these patterns of children's previous ideas about breathing and smoking may be relevant for teachers to use them in the process of pupils' conceptual change.

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THE CONTRIBUTION OF SECONDARY SCHOOL SUBJECT TEACHERS TO THE EDUCATION FOR SUSTAINABLE DEVELOPMENT

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Abstract: Education for Sustainable Development (ESD) integrates the principles, values and practices of sustainable development into all aspects of education and learning. The aim of this survey is to provide new information concerning to what extent subject teachers take different aspects of sustainability into account in their actions and teaching at school. Questionnaires with Likert-type scales were used to study the answers of 442 subject teachers from 49 schools in Finland. The data was reduced with a principal component analysis and an analysis of variance was used to compare teachers' answers. Depending on the subject, all teachers had specific strengths and limitations when implementing ESD at school. For instance, biology and geography teachers considered ecological sustainability significantly more often than other teachers, while language teachers were active in the education of cultural sustainability. In general, the subject was a more important factor in explaining the differences among the teachers than the teacher's gender or age. An awareness of one's strengths and limitations is important for subject teachers in order to develop their actions, teaching and co-operation in ESD at school. This study was carried out as a part of the SEED project, financed by the Academy of Finland.

Keywords: Education for sustainable development, subject teachers, lower secondary school, gender, age, large-scale survey.

INTRODUCTION

The aim of Education for Sustainable Development (ESD) is to integrate the principles, values and practices of sustainable development into all aspects of education. During the last decade, ESD has been increasingly taken into account in formal education around the globe (UNESCO, 2009). The consideration of all aspects of sustainability is important in ESD, though aspects involving ecological dimension have traditionally been emphasized (Rajakorpi & Rajakorpi, 2001; Pepper & Wildy, 2008; Breiting & Wickenberg, 2010). In Finland, according to the National Core Curriculum for Basic Education (NFBE, 2004), natural diversity and preservation of environmental viability is included in the underlying values of basic education. The curriculum also includes "Responsibility for the environment, well-being and a sustainable future" as a cross-curricular theme and, according to the NFBE (2004, p. 39), schools should teach "future-oriented thinking and the building of the future upon ecologically, economically, socially and culturally sustainable premises". In the learning objectives and core contents of different school subjects, goals linked to ESD are also mentioned. Thus, subject teachers have an important role in teaching sustainability issues.

In Finland secondary school subject teachers are specialized in two or three academic disciplines. The qualification required for subject teachers is the master's degree at a university. For their master's degree, subject teachers need to have completed basic, intermediate and advanced studies in their major subject, and basic and intermediate studies in their minor subjects, one of which is pedagogical studies at a department of teacher education in a faculty of behavioural sciences. These studies take about five years, but do not include special courses on ESD. However, sustainable development is a complex and controversial subject, and for the discipline-based teachers ESD may be a challenge.

According to UNESCO (2009), one important aspect in ESD-related research is to identify and analyze ESD's evolving contribution to the educational community. For instance in Finland, ninth grade students' pro-environmental and pro-social values and attitudes as well as their interest in environmental and human issues have been found to be interconnected (Uitto and Saloranta, 2010). Uitto, Juuti, Lavonen, Byman and Meisalo (2011) also found that ninth grade students' interest, values and attitudes to science-related environmental issues correlated with each other. To develop ESD at school, it is important to know how the teaching on sustainability issues by different subject teachers meets the world of today's lower secondary school students. This study was carried out in a subproject of a Finnish SEED research project *Sustainable Food Education for Self-Efficacy Development – SEED – How to encourage future citizens to act for a sustainable society,* 2009-2011. Specific questionnaires to survey the factors behind primary and secondary teachers', students' and headmasters' sustainable actions at school were developed. The aim of the present study is to figure out to what extent subject teachers take different aspects of sustainability into account in their 'whole-school-approach' actions and teaching at school. In this study, teachers' activities in all fields of sustainability were investigated. The questions for our research are:

- How often subject teachers implement different aspects of sustainability in their actions at school and in their own teaching?

- Do subject teachers differ from each other in teaching ecological, economic, social and cultural sustainability?

- What is the relative importance of gender, age and the teacher's subject in explaining the results?

MATERIAL AND METHODS

The data was collected in February 2010 in Finland. The questionnaire contained sections to elicit responses from teachers on items concerning actions and teaching on ecological, economic, social and cultural sustainability at school. For instance, the teachers were asked how often they used to carry out 'whole-school approach' actions, such as saving energy or materials at school, or considered different aspects of sustainability in their teaching. The commonness of different activities was rated on a five-point Likert-type scale: 5 = very often, 4 = rather often, 3 = sometimes, 2 = rather seldom, 1 = very seldom.

Fourteen questionnaires were sent to each of the randomly selected 54 lower secondary schools, of which five were Swedish - speaking schools. Altogether 49 schools returned questionnaires from 442 subject teachers (316 women and 122 men). The response rate for the selected schools was 92%, and for the teachers' questionnaires, 60%. The teachers were grouped to four different age groups: 21-30 years (13%), 31-40 years (25%), 41-50 years (31%) and >51 years (30%). The teachers were also grouped according to their major subject. The grouping was made using a combination of two subjects, if the teaching subjects were closely connected as major and minor subject and usually taught by the same teacher, such as mother tongue and literature, history and social studies, physical and health education, or religion and ethics. Finnish as the mother tongue and Swedish as a second national language were the most common subjects of the language teachers. The third common language was English. Because there were not many language teachers that had Finnish as second national language or French, German, Russian and other language as their major subject, they were combined to form a group of “other language teachers” in this study. Altogether 16 teacher categories were formed. A principal component analysis (PCA) was used to identify the latent variables. Summed scales were calculated by summing up original items according to the model of the PCA. The summed scales were then rescaled from 1 (lowest) to 5 (highest) (Table 1).

RESULTS

In the summed scales, the number of items varied between two and ten and the internal consistency (Cronbach’s alfa) from 0.4 to 0.9. Social sustainable actions, meaning co-operation and actions for the welfare of students and others teachers, were the most common contribution of subject teachers to ESD at school (Table 1).

Table 1. Means and standard deviations of the summed scales. *M* = mean, *SD* = standard deviation.1=lowest score, 5=highest score.

PCA	*Latent variables*	*N of items*	*Index of commonness*	
1	*One’s own sustainable actions at school:*		*M*	*SD*
	- Ecological sustainable actions	4	2.7	0.8
	- Co-operation in and outside the school	4	3.0	0.8
	- Social sustainable actions	5	4.2	0.4
	- Saving materials & energy in own work	2	4.0	0.8
2	*Ecological and economic sustainability in one’s own teaching:*			
	- Environmental issues	9	2.5	0.9
	- Sustainable food chains	3	2.4	1.0
	- Consumption habits	4	2.8	0.9
	- Recycling & waste sorting	3	4.1	1.0
3	*Social and cultural sustainability in own teaching:*			
	- Cultural heritage & multicultural issues	8	2.8	1.0
	- Tolerance & human wellbeing	6	3.5	0.8
	- Democracy at school & local level	4	2.7	0.9
	- Food in different cultures	3	2.7	1.1
4	*Consideration of values and responsibility in one’s own teaching*:			
	- Environmental values & responsibility	10	2.6	0.8
	- Challenges in economic sustainability	5	2.4	0.9
	- Human values & responsibility	4	3.4	0.9
5	*Self-efficacy in teaching*:			
	- Ecological sustainability	5	2.9	0.7
	- Social sustainability	6	3.3	0.5
	- General teaching, interaction with students	4	3.7	0.5
	- Influencing decision making at school	3	3.6	0.7

Ecological sustainable actions, such as saving materials and energy, were also common among teachers. More demanding sustainability actions, such as attempts actively to develop ESD at school were carried out less frequently.

In teaching, in terms of ecological sustainability the most often considered themes were recycling and waste sorting, while more specific themes, such as environmental issues and consumption habits were considered frequently. In social sustainability, tolerance and human wellbeing were quite commonly considered themes. For values and responsibility, human aspects were more commonly considered than ecological or economic aspects. Teachers' self-efficacy was higher in general teaching and interaction with the students or in influencing decision making at school than teaching ecological or social sustainability.

Examples of teachers' activity in considering different themes of sustainability are presented in Figures 1-2. For instance, biology and geography teachers contributed more often to education on environmental issues than all the other teachers (Figure 1). Recycling and waste sorting were also considered most often by biology and geography teachers, but also in home economics, visual arts and crafts. Sustainable food chains were considered most by the teachers of home economics, but consumption habits occasionally also by other teachers.

Tolerance and human wellbeing was rather commonly considered by all teachers, especially by teachers of home economics, physical education, biology, geography, religion and music (Figure 2). Democracy at school and at local level was considered mostly by the same teachers as those just mentioned above, but it was a more demanding issue. Cultural heritage and multicultural issues was considered most by the teachers of mother-tongue, history and social sciences, religion and ethics, music and visual art. Food in different cultures was considered most by the home economic teachers.

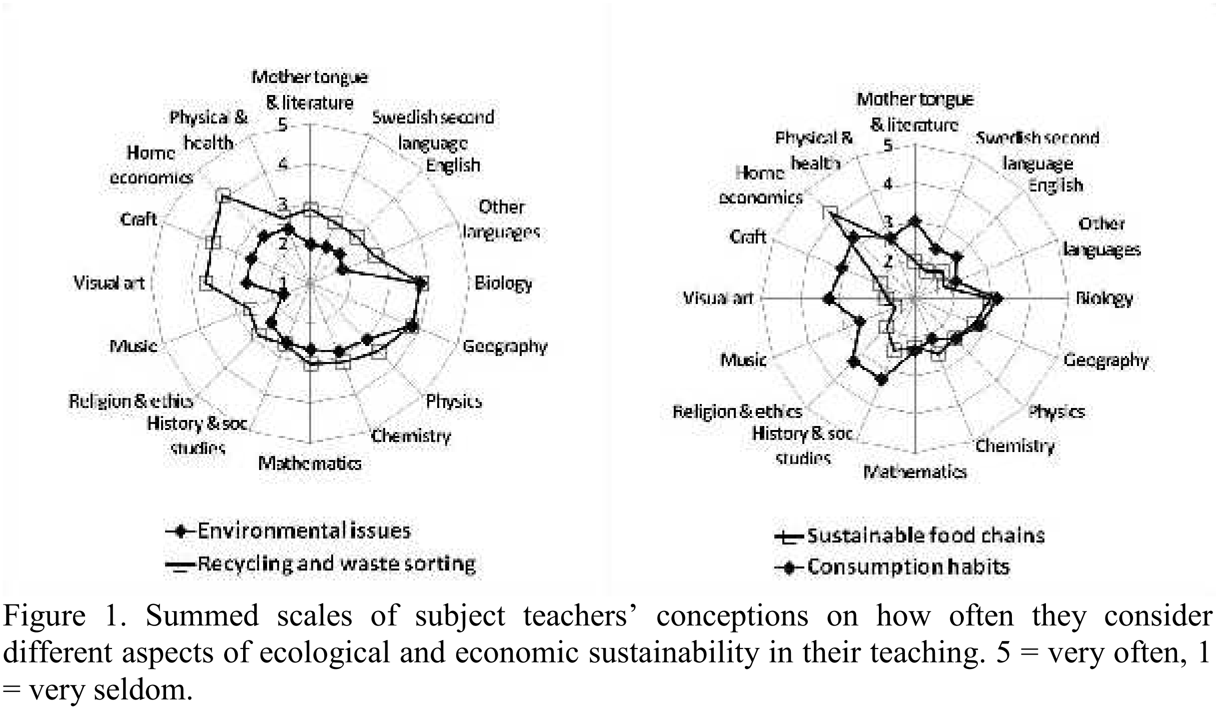

Figure 1. Summed scales of subject teachers' conceptions on how often they consider different aspects of ecological and economic sustainability in their teaching. 5 = very often, 1 = very seldom.

To figure out the relative importance of the independent variables, multivariate analysis of variance was conducted with the sex or age group and the subject of the teacher as independent variables. Teaching on environmental issues, consumption habits, recycling and waste sorting, cultural heritage and multicultural issues, tolerance and human wellbeing, and democracy at school and local level were the dependent variables.

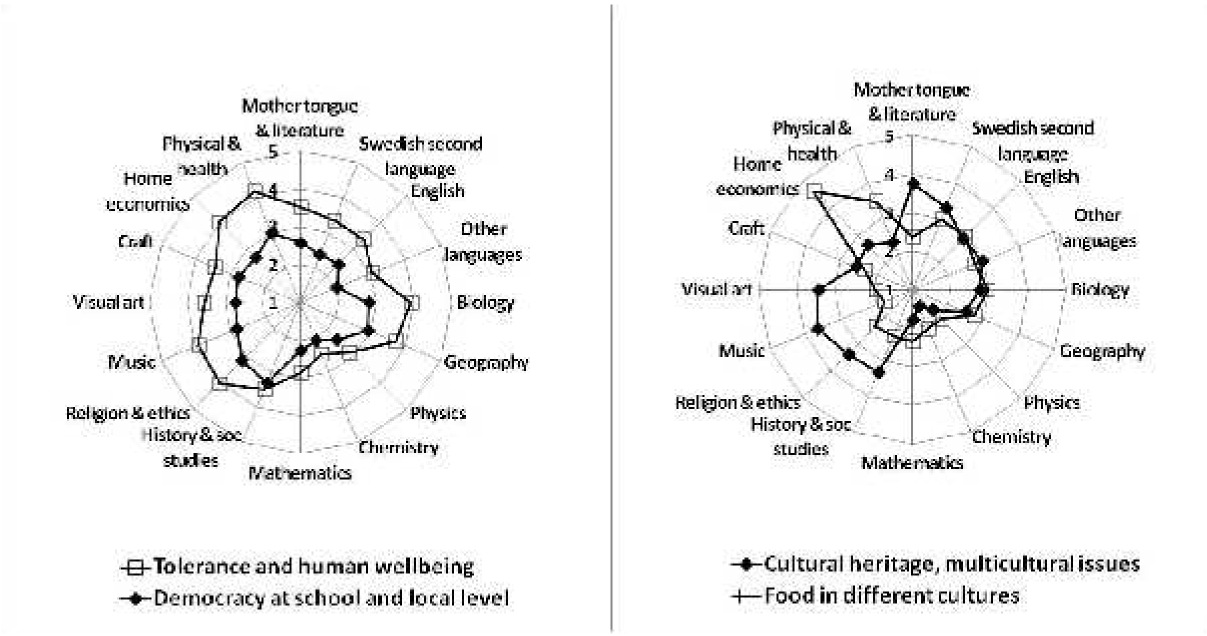

Figure 2. Summed scales of subject teachers' conceptions on how often they consider different aspects of social and cultural sustainability in their teaching. 5 = very often, 1 = very seldom.

When studied in association with gender, the effect of a teacher's subject was significant and large ─ Wilk's Lambda = .16, $F(90,2194) = 9.31$, $p < .001$, $\eta^2_p = .26$. The effect of gender was also significant ─ Wilk's Lambda = .95, $F(6,389) = 3.71$, $p = .001$, $\eta^2_p = .05$. There was also a significant interaction between gender and the teacher's subject ─ Wilk's Lambda = .74, $F(90,2194) = 1.33$, $p = .02$, $\eta^2_p = .05$. Follow-up pairwise comparisons showed that for instance democracy at school and at local level was more commonly taught by male than female teachers. When was the association between age and teacher's subject compared, the effect of the teacher's subject was again significant and large ─ Wilk's Lambda = .88, $F(18,1019) = 2.4$, $p < .01$, $\eta^2_p = .29$. The effect of age was also significant ─ Wilk's Lambda = .13, $F(90,2031) = 3.71$, $p = .001$, $\eta^2_p = .04$. In general, the oldest age group (> 51 years) used to consider sustainability issues more often than the youngest age group (21-30 years).

CONCLUSIONS AND IMPLICATIONS

During the past few decades ESD has been understood mostly as education concerning ecological aspects in Sweden and Denmark (Breiting & Wickenberg, 2010) and in Finland (Rajakorpi & Rajakorpi, 2001), although it should be more holistic including economic, social and cultural sustainability. Although a "whole school approach" is important, subject teachers have a specific opportunity to integrate different aspects of sustainability into their everyday teaching.

This study revealed that all subject teachers took aspects of social sustainability, such as tolerance and wellbeing rather often into account, in their everyday actions and in their teaching. However, depending on the subject, all the teachers had specific strengths and limitations, in terms of considering ESD. For instance, ecological sustainability, environmental values and responsibility were important for biology and geography teachers, but very rarely considered by language and music teachers. Teachers of physics, chemistry and mathematics occasionally considered fact-based ecological sustainability, but their contribution in economic, social and cultural sustainability was low. Language teachers were most active in cultural sustainability, but they rarely considered economic and ecological viewpoints in their teaching. In her study, Borg (2011) found similar results when studying how teachers from different disciplines understand and implement education for sustainable development in their teaching in Sweden. Her results showed that there were many subject-bound barriers to the successful implementation of ESD.

Awareness of the strengths and limitations of one's own teaching and awareness of other teachers' ways of considering sustainability issues would be important for subject teachers, when developing their 'whole-school approach' actions, teaching and co-operation in ESD at school. ESD should be taken into account in teacher education and when organizing further training for in-service subject teachers so that their discipline-based special know-how and needs for development are also taken into account.

The analysis of the SEED data will be continued in the future, by for instance studying the interaction between teachers and students in ESD.

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GLOBAL WARMING: A CASE STUDY OF EIGHT FRENCH TEACHERS' INVOLVEMENT IN EDUCATION FOR SUSTAINABLE DEVELOPMENT

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Abstract: Inclusion of global climate change (GCC) in education for sustainable development (ESD) challenges this socioscientific issue being particularly complex with contradictory scientific data as well as ethical and social considerations.

In order to analyse how teachers deal with this issue, we asked two groups of four high school teachers of different disciplines how they integrate this topic when teaching 16-18 year old students. We proposed to develop teaching resources for ESD, using mediated productions concerning GCC issues.

Our analysis of their proposals and interviews showed that teachers prefer to develop individual disciplinary resources, preserving the integrity of their teaching discipline, hence giving a representation of non-socialized science. Their own ecological beliefs and their epistemological approach, mobilizing allies' media supports, were focused on different controversial and educational aims, corresponding to *positivist*, *interventionist* or *critical education*. Between neutrality, balance and commitment, four teaching attitudes appear, depending on the personal interpretation of the teacher's role in ESD. Nevertheless, collectively, with a multidisciplinary approach which is not adapted to the complexity of the topic and despite a declared neutral and impartial approach, the educational aim is more critical, for instance including discussions about political choices of nuclear energy or biofuels to alleviate the GCC.

Because facing a socioscientific issue leads to different controversial educational aims, this case study militates for a national debate around professional and educational ethics promoting a democratic commitment of students.

Keywords: climate change, sustainable development, teachers' attitudes, education, ethic.

THEORETICAL BACKGROUND AND RATIONALE

As Sadler and al. (2006) noticed, *part of the complexity inherent to socioscientific issues stems from their inevitable associations with ethical considerations* […]. *Ethical concerns are among the most important factors for individual socioscientific decision-making*. Fixing attention on mediated and controversial discourses regarding the human responsibility on global climate change (GCC) shows that ethical and epistemological conflicts are expressed. That's why we consider connections between climatic risks assessments and the political project of sustainable development as a socioscientific issue. Because global warming is not a free-value issue, in an educational project for citizenship facing this topic, values should not be excluded: *values help establish how science is conducted and help determine how results are interpreted and used* (Sadler and al., 2006).

In France, ten years after the Rio summit (1992), the promotion of education for sustainable development (ESD) defined national standards (Ministère de l'éducation nationale, 2004 and 2007), perhaps with *the intention of persuading people* […] to *promote the policies that will help to alleviate* socioscientific problems (Gayford, 2002) like GCC. But several stakeholders declared that the educational aim could not be teaching persuasive choices but rather an education for responsible choices, enabling the democratic empowerment of students. To solve this ambiguity, they suggested teachers maintain an attitude of neutrality in order to avoid students' indoctrination (Cotton, 2006). This neutral position was criticised by Kelly (1986) and Oulton (2004). According to them, if teachers make their own position explicit facing a socioscientific issue and encourage students to criticize them alongside other positions, then youthful citizens will be aware of potentials bias and encouraged to develop an independence of thought, understanding the complexity of the issue studied.

We consider that ESD must be a critical education *for democratic and transformative action* (Giroux, 1987) in which teachers could adopt *commitment impartiality* around democratic values, rather than the *myth and misguidance of a value-free and non disclosing neutrality*. The educational aim is to *catalyze the critical intelligence and civic courage of both youthful citizens and ourselves* (Kelly, 1986).

PURPOSE AND RESEARCH QUESTION

Our research aims to analyze and discuss this controversy regarding educational aims and teachers' attitudes. Through the proposition of including the GCC issue in French ESD program, our research question is how eight high school teachers deal individually and collectively with the complexity of a not-free value issue and with the expression of their own beliefs in an educative project.

Methods

Teacher Sex	*Subject taught*	*Area of exercise*	*Highest degrees*	*Levels of experience*
F	Physics - Chemistry	*High school in Grenoble*	*Bachelor*	*15 years*
F	Biology - Geology		*Master*	*5 years*
M	History - Geography		*Master*	*4 years*
F	Economics - Social sciences		*Master*	*4 years*
F	Economics - Social sciences	*High school in Lyon*	*Bachelor*	*26 years*
M	Physics - Chemistry		*Master*	*12 years*
M	Philosophy		*Bachelor*	*12 years*
M	History - Geography		*Master*	*6 years*

Table 1: high school teachers' background information

Involved in an annual work contract with the French institute for educational research (INRP), two groups of four high school teachers (teaching natural science or social science) have accepted to develop resources related to GCC issues, in order to contribute to teacher training for ESD.

For eight months, from November 2006 to June 2007, we interviewed them on *educational aims*, *mediated supports choices* and *socioscientific discourses* on their teaching proposals published on a public website for teacher training.

Each teacher produced an average of nine proposals and was interviewed twice, for individual semi-structured interviews lasting about 90 minutes. For each group of four teachers working in the same high school, two workshops of two hours were organized in June 2007, an occasion to highlight the *dominant doxa* regarding ESD. All these exchanges were audio-recorded and transcribed to analyse the teaching model supporting proposals and the teacher's pedagogical involvement on ESD.

RESULTS

According to the discipline they taught, teachers have produced disciplinary resources exploring concepts like the physics of the greenhouse effect, the global carbon cycle, the geography of climate risks, the demography, sustainable development and economy, or the philosophical analysis of the relationship between nature and technology.

But independently of the subject taught, different aims for ESD appear for each teacher. Adopting a neutral and balanced attitude (the mythic *neutral impartiality* according to Kelly, 1986), in order to avoid using their position of authority to promote their own opinions, teachers all declared they wanted to help students develop civic capacities critics.

For half of the teachers, convinced by man-made climate change, this socioscientific issue must contribute to make students aware of the environment, like a pretext-object used to achieve an *interventionist educational aim*. They used partial mediated supports like the documentary film *an inconvenient truth* (Guggenheim, 2006) where controversies are excluded. Medias are used like allies, especially when mediated beliefs about GCC are shared with the teacher. In this case, the teacher followed an *exclusive partiality* attitude (Kelly, 1986).

Some other teachers achieved *a positivist educational aim* when they considered that they were not able to deal with complexity and ethical considerations of the socioscientific issue. Because they exposed students exclusively to official and consensual disciplinary content, their attitude was an exclusive *neutrality* (Kelly, 1986).

In the same high school in Lyon, geography and philosophy teachers proposed a *critical educational model* where controversies of the question were not avoided. In an individual but multidisciplinary approach facing epistemological and ethical considerations, different mediated viewpoints were exposed. Both teachers adopted an attitude that could be qualified as *impartial commitment* (Kelly, 1986). But with an educational approach far from interventionist national ESD standards adopted by his colleagues, the geography teacher felt then a risk of marginalization.

During collective workshops, the individual tendency to maintain the integrity and the legitimacy of his/her own discipline lead to a pluridisciplinary fragmentation of socioscientific complexity. But in this context, all teachers adopted a common critical educational aim. They collectively decided to deal with topics related to political solutions presented like alleviations against GCC (nuclear energy in the high school of Lyon, and biofuels in Grenoble). Excepting the philosophy teacher who was convinced by the necessity of adopting an attitude of impartial commitment facing socioscientific controversies, they all supposed that they had to expose disciplinary and free-value knowledge, adopting a neutral attitude in debates, in order to leave students developing critical viewpoints by themselves about complexity and the values of the GCC issue.

CONCLUSIONS AND IMPLICATIONS

It seems that many parameters must be taken into account to analyse declarations and teaching proposals of the eight teachers. In the teaching context, they dealt with the balance between their *ecological beliefs* of human responsibilities on socio-environmental crisis and their *epistemological viewpoints* of the scientific assessments. Their visions of the *teacher's attitude* facing a controversial and not free-value topic must also be taken in account. All these parameters lead to three kinds of educational aims, where different attitudes are related to the *supposed influences* that the teacher could have on students' viewpoints.

Even if the disciplinary fragmentation of complexity could be an impediment for integration of a socioscientific topic, we noticed that collectively a shared critical educational aim is expressed which erased the interventionist model. Through debates between teachers, the collective situation could indicate possible progress toward a democratic citizenship education.

For a teaching inclusion of complex data and ethical considerations, we have seen that *impartial commitment* attitude was not unanimously adopted and so probably controversial. If we refuse to debate collectively with ethical considerations that are among the most important factors for individual decision-making, especially around the perspective of a common future of humanity, we risk rendering the democratic project of a civic ESD insignificant. Because excluding complex and ethical dimensions from teaching lead to a depoliticization and a disempowerment of teachers' activities, and so impede the student's training for active participation in a society largely influenced by science and technology, a breakdown of the traditionally supposed free-value teaching is necessary. Today there is a need for debates on the professional ethic for teaching a socioscientific issue, in order to restore the global meaning of citizenship in science education and to unlock a potential for pedagogical innovation.

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SCHOOL SCIENCE AND PUBLIC AWARENESS: A GEOLOGICAL WALK THROUGH TIME (FOZ DO DOURO - PORTO, PORTUGAL)

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Abstract: Citizens need to be scientifically literate in order to be able to contribute to decision making about issues that have scientific dimension. In order to help school science to promote citizenship, a field trip was organized according to Orion's model (1993), in a beach area called Foz do Douro in Porto, Portugal. The field trip had six study stations and educational materials, (including posters, field guides, banners and a film) were specially elaborated to help students and lay visitors to follow the cover story – a geological walk through time. Many school contents were taught during the field trip, helping the curricular development, but it also had the intention of public awareness of geological aspects like, for example, geological heritage. Literature revision reminds us that it is necessary to promote such field activities so that geology is learned through practice and not only from books. Although attempts to link school science and citizenship tend not to be successful in the long term, it was expected that field trips, science school and public awareness of science, together could promote the achieving of a scientifically literate citizenship.

Keywords: school science, public awareness of science, field trip, citizenship, Orion's field trip model.

FIELD TRIPS, SCHOOL SCIENCE AND PUBLIC AWARENESS OF SCIENCE

The 21st century strengthened Science Education goal to involve students in lifelong education and to participate in the on going debates about the changes occurring in society, reinforcing the need to develop citizenship competencies. This goal raises (again) the question of what kind of education in science would prepare students for their role as citizens in a rapidly changing world? Although the answer to this question may consider a number of justifications, we have to recognize the value of enhancing the public awareness of science as a social responsibility that can, and should, help the school science education to involve scholars in 'citizen science' (Jenkins, 1999). The fact is that, besides helping lay citizens understand a number of important scientific concepts, public understanding of science has implications for the form and content of school science education. This concern of school science classes to prepare students to play a constructive role as citizens in the society is perhaps the major focus of international projects, like TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment), which emphasise the importance of developing the scientific literacy of students. Hence it is natural to require a relationship between school science and the general public's awareness of science, fact that led to the recognition of science learning as taking place in a continuum of formal and informal venues (Gilbert, 2010).

Due to the fact that little was made for the general public, learning science in informal environments is growing rapidly in extension and diversity. Informal education has acquired increasing importance as an element of promoting activities which enhance the public understanding of science and also as a complement to formal learning. Although we know that the public's awareness of science had developed not due to school experiences but to popularizers of science (Fensham, 1999), we all recognize the relevance of interactive museums and public science centres as important educational resources.

A field trip is another educational means that has an important role to play in developing student's scientific literacy and enhancing both cognitive and affective dimensions. According to Fuller et al. (2003), students perceive fieldwork to be beneficial to their learning, because through it they develop subject knowledge, acquire technical and transferable competencies, and interact socially with their teachers and peers. The same authors also claim that the value of field trips lies particularly in providing students with a better sense of the real world and direct experience with concrete phenomena. It can be developed as both a formal curriculum activity and as an informal awareness of science experience (Lima et al., 2010). These informal activities are not always conducted in a manner that maximise learning. However, considering the importance of field trips regarding school science and public awareness, a geological walk through time in Foz do Douro (a beach area in Porto, Portugal) was organized.

Considering the need to find a theoretically supported alternative to the kinds of field trips generally put into practice, the research team decided to organize this activity based on the model proposed by Orion (1993) (although some necessary adaptations were made, so as to promote the field trip as both formal and informal). Many geological contents were taught during the field trip (geological dimensions of time and space; different types of rocks, rock erosion …), ensuring the curriculum development and also aiming to promote public awareness, namely preserving geological heritage. It is necessary to develop such field trips so that geology is learned through practical work in an outdoor environment, rather than just from a theoretical perspective (Van Loon, 2008).

The field trip: A Geological walk through time (Foz do Douro - Porto, Portugal)

Some members of the Centre of Geology of the Faculty of Science of Porto University with members from the Porto Townhall organized a field trip in Foz do Douro, both as a learning resource, for middle and high school's students, and as a public understanding of science activity.

According to Orion's model (1993), in formal field trip activity, the stage of preparation for a field trip takes place in the classroom or laboratory and can be of variable duration. Orion e Hofstein (1994) point out the importance, in this unit, of reducing the "novelty space" (psychological factors, geographical factors and cognitive factors) to the minimum, related to how familiar the visitor is with the place to be visited. However, in this field trip, used as a formal learning resource and as an informal public awareness activity, this preparation unit did not occur in the classroom. The pre-visit unit was given by a monitor as soon as the students and lay visitors arrived at the location. The monitor resorted to a trip guide and a film illustrating the geological history of the area that were specifically produced for this field trip. In each one of the six study stations in the second unit of the field trip, considered the core unit of the module, trip guides, posters (figure 1), instruments of orientation, and other educational materials were used. It was expected that a post-trip unit would take place in the classroom (formal activity) or in the small centre which had been created to welcome the visitors (informal activity).

Figure 1. Poster in Foz do Douro

Figure 2. Students during a field trip

The cover story of the field trip involved a geological walk through time in an area extending over a series of small beaches between the Douro river mouth and the S. Francisco Xavier fort. The geological story of this metamorphic complex began many million years ago at a time when planet Earth was very different from that which we know today. In fact, both the film elaborated to reduce novelty space and the study stations selected invited the visitors to go back in time, to about 1000 million years ago, when supercontinent Rodinia was being formed.

Continuing the field trip, visitors travel through the break up of Rodinia, about 750 million years ago and the regrouping of its fragments to form Gondwana, about 650 to 550 million years ago. The field trip finishes in outcrops formed during Carboniferous and Permian periods (359- 251 M.y.). With the closure of the Rheic Ocean in this period, the Laurasia and Gondwana continents collided to subsequently form the Pangea supercontinent.

The origin of the variety of rocks observed during the visit can be explained by the story of these geological events. This area has also been classified (since 2001) as municipal natural heritage because it constitutes one of the rare outcrops of the city that demonstrates unique characteristics such as variety of lithologies, geological structures and geomorphologic features (figures 3 and 4). In fact, these outcroups constitute a natural laboratory where an understanding of geological phenomena and events become more accessible.

All of these aspects make this area a privileged place for those school teachers involved in teaching Natural Sciences or Geology.

Figure 3. Giant pot

Figure 4: Folds

On the other hand, it is also a Geological Heritage of undeniable scientific and educational value that can be used in a field trip with both cognitive and social gains, demonstrating that school science and public awareness of science together can promote the achievement of a scientifically literate citizenry.

CONCLUSIONS AND IMPLICATIONS

As citizens must be scientifically literate in order to contribute to decision-making about issues that have a scientific dimension, school science uses informal activities as educational resources. The geological "walk through time" developed in Foz do Rio Douro is an example of how a field trip can be developed as a continuous formal/informal activity of teaching, learning and science awareness.

In 2008 the Interpretative Centre (where some complementary activities in the field trip can take place) opened to school visits and to general public, having received an interesting media coverage. Because Foz do Douro is often visited by many tourists, the field guides and posters were written in Portuguese and English and pamphlets were also divulged in French and Italian.

Finally, this project was funded by the Foundation for Science and Technology (FCT-Portugal) and regarding the quality of the educational materials and the importance of the geological awareness, Porto Townhall won an honour mention in 2005 and the Geoheritage prize in 2009, both given by the group ProGeo-Portugal (The European Association for the Conservation of the Geological Heritage).

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REEXAMINATION OF HOW A SCIENCE MUSEUM SHOULD BE AND ITS REGENERATION AS A COMMUNITY-BASED MUSEUM

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Abstract: the Gamagori Museum of Earth, Life and the Sea had been an exhibition-centered museum. Those who visited the museum once, rarely revisited. Thus, the number of visitors during 2009 dropped to 19,256. In an attempt to reverse this trend, various plans have been implemented since 2010 such as science workshops and school visit programs. As a result, the number of visitors increased to 34,435, 1.79 times higher than the previous year. The number of visitors for paid exhibitions reached 23,031 in 2010 compared with 18,395 in 2009, an increase of 1.25 times. The workshop participants also visited the exhibition room, which means the workshops and other experience-oriented programs attracted new visitors. Moreover, 55 schools and institutions, 3,764 students and teachers participated in the school visit program, which fostered closer cooperation with schools. Through these programs, a local human resource network has been formed, establishing a system whereby the local community supports its science museum.

Keywords: reform of a science museum, cooperation with schools and local communities, establishment of human resource network, workshop

PURPOSE

It is widely pointed out that science museums should strengthen cooperation with society. In relation to the issue of how museums should cooperate with local schools, Griffin (1998) investigated a framework to facilitate students' learning in museums. Kawakami et al. (2003) proposed ways to use science museums in school education. Braund and Reiss (2006) proposed that laboratory-based school science teaching needs to be complemented by out-of-school science learning that draws on the actual world (e.g. through fieldtrips), the presented world (e.g. in science centres, botanic gardens, zoos and science museums), and the virtual worlds that are increasingly available through information technologies. The Minister of Education, Culture, Sports, Science and Technology of Japan (2008) recommended that schools use science museums and similar facilities as educational tools. Marcotte (2007) proposed a Web-based technology to support learning through museums. Yamanaka and Kawakami (2008) conducted science lessons for senior high school students at museums, and these lessons were highly regarded by the students who attended.

The Gamagori Museum of Earth, Life and the Sea is a science museum located in a small city with a population of about 80,000 in Japan. Due to financial difficulties and a decrease in number of visitors, discussions were held on how the museum should be reformed, keeping in mind the possibility of closure in 2007. After one year of intensive discussions, it was decided to continue the museum for the Gamagori citizens, based on its close relation to the local community and focusing on the collaboration with the local community and schools.

The objectives of the reform strategies are as follows:

- To promote frequent visits to the museum by elementary school students and their parents, through incorporating hands-on experience into the museum's programs.
- To strengthen collaboration with schools by providing science classes at schools and enhance the museum's identity as "a science education facility in cooperation with school education".
- To establish a "human resource network" organically connecting people who want to learn and people who want to teach or disseminate information, in cooperation with members of the local community, including residents, companies, universities, schools/other educational institutions, and tourism facilities so that the museum can function as a hub for science education. On top of that, this network will encourage more frequent utilization of the museum by local people by functioning as a regional "lifelong learning and community activity center".

With the aim of contributing to the revitalization of museums and science museums, this report introduces the successful case of the Gamagori Museum of Earth, Life and the Sea, which was once in a moribund state, but which has revived and experienced a dramatic increase in the number of visitors, by implementing various reform measures.

METHODS AND STUDY PERIOD

Subject:

Gamagori Museum of Earth, Life and the Sea, in Gamagori City, Japan

Period:

This report covers the results of reform measures implemented from April 2010 through March 2011.

Questionnaire surveys

Three types of questionnaire surveys were carried out in order to clarify the current state of the museum:

- A survey on how the museum is utilized was conducted with all teachers in Gamagori City in April 2010. The questionnaires were sent to 418 teachers and 208 of them answered with the response rate 49.8%.

- Surveys were occasionally conducted with workshop participants from April 2010 to March 2011.
- Another survey was conducted in November 2010 of 28 lecturers and event organizers who took part in the workshops/science shows during August 2010.

RESULTS

Specific reform measures

- Holding science shows and workshops:
  In cooperation with teachers of the neighboring communities and local companies, the museum held science shows and workshops everyday during the May Golden Week and the August summer vacation in 2010. From September onward, such events took place every Saturday and Sunday. 48 lecturers and organizations were invited to the events, including 10 researchers, 8 teachers, (1 Education Center, 1 senior high school, 1 junior high school, 5 elementary school), 19 companies, 11 senior citizens' organization and others. The titles of the science shows were "Let's Fly Solar Balloons!", "Chemical Magic Show", "Wow! How Mys-te-rious Light Is!" while those of the workshops were: "Manufacturing One-Transistor Radio", "Bio-adventure", " An Experiment of Surface-Active Agent"," What Is Fermentation Technique?" and so on.
- Holding lecture meetings:
  Three lecture meetings designed for adults were held with lecturers invited nationwide.
- Holding science seminars:
  The target audience is adult citizens with lecturers selected from among Gamagori citizens. Three seminars were held at intervals of two months.
- School visit project:
  Museum staff visited schools to provide classes of science or integrated study. Not only science lessons but also teacher training and extracurricular activities were carried out according to requests from schools and teachers. A total of 55 visits were made.
- "Easy-to-understand, visitor-friendly" exhibition
  In pursuit of "easy-to-understand and visitor-friendly" exhibitions, various improvements were introduced such as an audio-guide developed by the museum's academic staff and new explanatory panels. An area was created in the museum where the scientific achievements of schools and companies in Gamagori are exhibited.
  Although these improvements were made to the exhibition room on the third floor, substantial refurbishment is scheduled during FY2011 onward because of the limited budget. Overall, there has not been a considerable change in this respect.

The results of the questionnaire survey with teachers

As shown in Table 1, 71 teachers have visited the museum only once. While 39 teachers have never been to the museum, 38 teachers visit rather occasionally.

As for what they desire for the museum, according to Table 2, in total 131 respondents would like science shows and workshops. As many as 64 respondents referred to school visit program in which science lessons are provided by the museum staff.

Table 1. Frequency of visit to the museum

	Number of Respondents
Never been to the museum	39
Visited only once	71
Visit occasionally	38
Visit frequently	0

Table 2. What programs do you want to utilize in the future? (multiple answers allowed)

	Number of Respondents
Science shows	87
Workshops	44
School visit	64
Film shows	69
Digital materials	22

The results of workshop participant questionnaire

As shown in Table 3, 6 to 8 year-old age group had the largest number of workshop participants with 979 children, comprising 40% of the total, followed by 741 children in the 9 to 11 year-old age group that accounts for 30%. 70% of the total participants were elementary school pupils. These children were usually accompanied by their parents, the number of whom is not included in Table 3.

85% of the participants answered that the workshop was interesting. Including those who answered “moderately interesting”, 95% of the children enjoyed the program. (Table 4)

Table 3. Age distribution of workshop participants

Age	*Number of respondents*	*Percentage*
0 to 5 years old	204	8
6 to 8 years old	979	40
9 to 11 years old	741	30
12 to 19 years old	98	4
20 years and over	319	13
Others	99	4

Table 4. Satisfaction rating of workshop participants

	Number of Respondents	*Percentage*
Interesting	2036	85
Moderately interesting	233	10
Not interesting	20	1
Others	101	4

Event organizers’ opinions

A questionnaire was sent to 28 organizers of workshops and science shows and 21 of them responded.

The motives or objectives of their participation were as follows: contribution to society/community: 9; dissemination of science education: 5; and company public relations: 3.

Most of them answered that their original motives/objectives were fulfilled and 18 of them showed their eagerness to continue their activities. (The remaining 3 people did not answer.)

Change in number of museum visitors

Table 5 shows a comparison of the number of visitors in 2009 with those in 2010:
In 2010, 23,031 visitors entered the exhibition room. This is an increase of 4,636 visitors, 1.25 times higher than the previous year. The total number of visitors, including workshop and school visit program participants, reached 34,435, an increase of 15,179 visitors, 1.79 times up from the previous year. Here, "the number of visitors to the exhibition room" means the number of people who entered the exhibition room on the third floor, paying the admission fee. In 2009, the number of visitors who paid the fee to enter the exhibition room decreased to18,395.

Gamagori citizen visitors also showed an increase of 3,677, 1.36 times higher than and the number of Gamagori Citizenship cards issued was 960, 1.44 times higher than the previous year. (Gamagori citizens can visit the museum for free of charge if they possess this card.)

Workshop participants account for most of the "visitors for workshops, lecture meetings and science seminars". The number of people who attended the first lecture was 60, while for the second meeting the number was 40. Science seminars were very popular attracting 50 attendants for the first meeting and 20 for the second.

The most successful museum commitment is the school visit program. 55 classes were provided at schools and altogether 3,764 pupils, students and teachers attended.

Table 5. Number of museum visitors in 2010 in comparison with 2009

	2009	*2010*	*increase*	*Rate of increase*
Number of exhibition room visitors	18395	23031	4636	1.25
(Gamagori citizens)	(2710)	(3677)	(96)	1.36
(Number of Citizenship Cards issued)	(665)	(960)	(295)	1.44
Workshops/lectures/science seminars	100	7640	7540	76.4
School visit (science classes), etc.	761	3764	3003	4.95
Total	19256	34435	15179	1.79

Note: Figures in parenthesis indicate the number of visitors included in exhibition room visitors.

DISCUSSION

Increase in number of museum visitors

Griffin (1998) suggested creating a framework for utilization of science museums. The Gamagori Museum of Earth, Life and the Sea has launched new operating concepts of providing hands-on experience programs, such as workshops, and of encouraging cooperation with schools, as an addition to the previous policy of holding only exhibitions. A preliminary survey of teachers discovered that they would like the museum to incorporate various scientific experiences into the museum's programs and to conduct science lessons at schools. Thanks to the introduction of these new projects, the number of visitors to the museum has steadily increased. This trend proves that the museum's objective to promote visits by elementary school pupils and their parents through integrating hands-on experiences to the museum's activities has been fulfilled. The museum will continue to make efforts in this direction.

Workshops and other event projects

95% of the questionnaire respondents answered that the workshops were either "interesting" or "moderately interesting", showing a very high level of satisfaction. Braund and Reiss (2006) pointed out the importance of hands-on experience activities at a science museum. These survey results sustain their contention. It was found that senior high school students' intellectual interest increased after visiting the museum (Yamanaka and Kawakami, 2008). Ongoing efforts prove that the museum can offer a high level of satisfaction to elementary school pupils and younger children through implementing hands-on science experience programs such as workshops.

School visit project

Griffin (1998) and Kawakami et al. (2003) investigated the significance of utilization of science museums by schools. The Minister of Education, Culture, Sports, Science and Technology of Japan (2008) recommended that schools use science museums and similar facilities as educational tools. In the case of this Gamagori museum, the number of the cases in which schools made use of the museum's school visit program increased to 55.

This fact indicates that the museum's new policy of strengthening the partnership with local schools using the school visit project as a core has been well supported. Therefore, it can be considered that the objective of the museum reform as "a science education dissemination facility in cooperation with school education" has been attained.

Building a human resource network /role of the museum as a hub

The individuals and organizations that have collaborated with the museum since 2010 under the new system are linked and called "the human resource network". Currently 48 individuals and organizations constitute the network. Almost half of the museum's workshops and other programs were implemented, with lecturers invited from this human resource network. In other words, the local science education resources are passed back to the citizens through the museum's workshops and other programs.

In response to the questionnaire of this human resource network, almost all respondents indicated that they would like to take part in such programs again. This reaction shows that the creation of a human resource network, and its utilization as an educational resource, encouraged their involvement in the museum's activities. Functioning as a hub in science education, the museum can promote utilization of the facility by local residents and fulfill the museum's objective of being "a life-long education and community activity center".

Future challenges

Many of the workshop participants are elementary school pupils or preschoolers and the school visit program is utilized mostly by elementary schools. Therefore, the next challenge for the museum is how to motivate students of local junior high schools and senior high schools to visit the museum.

The expansion of experience-oriented programs led to an increase in the number of museum visitors, as well as exhibition room visitors. However, the refurbishment plan to make the exhibition room more "visitor-friendly" has not yet started due to a lack of funding. The implementation of the proposed plan is critical to enabling workshop visitors to enjoy the exhibition room more. A remaining challenge for the museum is how to formulate a system to foster more frequent exhibition visits from among those who visit the museum.

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SEX EDUCATION IN LEBANON AND FRANCE

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Abstract: This work is a comparison between France and Lebanon. It analyzes the conceptions of Lebanese and French teachers on issues concerning human sexuality and its education. Our goal is to highlight the different conceptions of teachers in both countries and to identify the parameters to which these differences are correlated. All the multivariate analyses conducted show two very different systems of conceptions, very significantly differentiating Lebanese teachers' conceptions of French teachers ones. French teachers, unlike their Lebanese colleagues, are more conducive to early learning topics related to sexuality to students between 6 and 15 years old depending on the subject. They are more likely to accept abortion and homosexuality, to focus on safer sex as an attitude that can reduce the spread of AIDS, and to consider that the teaching of STIs is not only the issue of biology teachers. The differences between Lebanon and France are not reducible to religion: each country has its own identity rooted in its specific geographical, historical, economic and cultural context.

Keywords: Sex education, Multiculturality, religion, conceptions, teachers

1 – Context and theoretical backgrounds

Sex education (SE) presents great interest at the international level. Research in several countries confirms that the promotion of SE does not encourage young people to have early sexual intercourse (Blum & Mmari, 2006, Kirby & Lepore, 2007) but rather put in evidence a positive effect on the maturity in the sexual behavior of students (Singh *& al*, 2005) and risk taking (Coyle *& al*, 2004, 2006 ; Kirby *& al* , 1997, 2005, 2006, 2007).

In 1994, WHO pointed out that sex education (SE) has to provide students, considering their representations and basics, with information and scientific knowledge that allow them to discover and understand the different dimensions of sexuality; WHO added that SE also seeks to stimulate students' thinking based on information provided to help them develop attitudes of individual, familial and social responsibilities.

According to the recommendations of international organisms such as WHO, the educational center of research and development in Lebanon (ECRD) has attempted to introduce SE in the renovated curricula of 1998. This attempt has faced many objections from several socio-political and religious authorities in Lebanon, which resulted in its total suppression from the curriculum of the EB8 class (students aged 12-13) (Circular n°35/M/99, Presidential Decree n°2066) and partial containment of the biology curriculum for the 2nd year of secondary school (15-16 years), Literature and Humanities and the 3rd year of secondary school (16-17 years) (Ministry of Education circular n°95/M/99, decree n°10227/97, Harfouch & Clément, 2001, Yammine & *al*, 2007, Yammine 2008).

Currently, a new attempt to reintroduce SE in the Lebanese teaching context is part of a project combining the efforts of the ECRD, the UNFPA (United Nations Population Fund) and the Lebanese Ministry of Education.

French curricula have, in turn, evolved considerably during the past 50 years in human sexuality. ES is currently ruled by laws and is defined as follows:
"The sex education's primary purpose is to provide students with opportunities to learn and understand the different dimensions of the –and their- sexuality, in accordance with the consciences and the right to privacy. This education, based on humanistic values of tolerance and freedom, self and others respect, should also help students to integrate positive attitudes of individual, familial and social responsibilities." (B.O N°. 46: Circular N°. 98-234 dated November 19, 1998, Sex Education and AIDS Prevention).
The introduction of SE in France was initially, and is still today, more directed to the biomedical dimension than to the promotion of health (Bernard & Clément 2005, 2007 Berger et *al*, 2007). SE in France has not met such strong resistance as in Lebanon.
Lebanese society is multiconfessional. To manage it, the Lebanese refer to the National Pact (unformulated agreement, not written, signed in 1943) to apportion the responsibilities in the government (Al-Khoury, 1956), "which gave birth a tradition where each community was responsible for providing education to its children as it wanted and where it wanted" (Quobeisy, 1998).
Beyond this diversity, there may be some Lebanese homogeneity in comparison with other countries. This relative homogeneity is in fact emerged in comparing conceptions of the Lebanese teachers to those of teachers from other countries on topics such as evolution (Clément & Quessada, 2008, 2009), or environment education (Khalil & *al*, 2007a and b).
It is for these reasons that we made a comparison of Lebanese and French teachers' conceptions, using samples large enough to identify a possible diversity of opinion within each country, but also to compare the two countries together, in order to identify whether, beyond their differences, the Lebanese teachers share common characteristics that distinguish them from their French colleagues.

Analyzed conceptions will take into account the teachers' knowledge, values and social practices (in relation to abortion, homosexuality...) and their pedagogical projects (what should or should not be taught and at what age).

2 - Research Question.

Do the Lebanese and French teachers conceptions on sexuality and SE mainly differ in terms of the nationality of these teachers (thus according to their national socio-cultural context) or are they rather based on other parameters such as their religion, the degree of belief and the religious practice, or even more on their political opinion?

3 – Methodology

It was developed in the context of the European research project Biohead-Citizen (Biology, Health and Environmental Education for Better Citizenship; 19 countries, including Lebanon and France). Teachers respond in writing, completely anonymously and in the presence of the researcher, to a questionnaire covering six topics, including reproduction and human sexuality and teaching (24 questions) as well as their religious, social and political opinions (17 questions), and other personal information (Clément & Carvalho 2007). The responses were subject to several types of multivariate analyses (Munoz & Clément, 2007, Munoz & *al*. 2009).

In each country, samples are strictly comparable: 1/6 in service teachers of primary schools (InP), 1/6 pre-service teachers of primary schools (PreP), 1/6 in-service teachers of biology (InB) in secondary schools (for Students 11 to 18 Years old), 1/6 pre-service teachers of biology (PreB) in secondary schools, 1/6 in-service teachers of language / letters (InL) in secondary schools, 1/6 pre-service teachers of language / letters (PreL) in secondary schools.
In total, 722 teachers and future teachers were surveyed in 5 regions of Lebanon (North, South, Mount Lebanon, Bekaa and Beirut) and 732 teachers and future teachers in two regions of France (Rhone-Alpes and Languedoc-Roussillon) (Table 1).

Table 1. Submission of samples surveyed in Lebanon and France. For the group of education (InB, InL etc.), cf. the text above. For religion, AGN = Agnostics, CHR = Christians, Muslims = MUS, ELS = most: "I do not want to answer" no answers + some, + a few other religions as AGN, CHR or MUS

		Lebanon	%	France	%
	Total Sample	722	100	732	100
Teaching groups	InB	153	21.2	100	13.7
	InL	111	15.4	110	15.0
	InP	246	34.1	114	15.6
	PreB	59	8.2	149	20.4
	PreL	56	7.8	101	13.8
	PreP	97	13.4	158	21.6
Religion	AGN	3	0.4	370	50.5
	CHR	217	30.1	304	41.5
	ELS	33	4.6	47	6.5
	MUS	469	65.0	11	1.5
Level of belief	1 (+)	700	97	131	17.9
	2	9	1.2	79	10.8
	3	4	0.6	97	13.3
	4	4	0.6	68	9.3
	5 (-)	5	0.7	357	48.8
Level of practice	1 (+)	556	77	44	6.0
	2	76	10.5	30	4.1
	3	38	5.3	9	1.2
	4	7	1.0	67	9.2
	5 (-)	45	6.2	532	72.7

4 - Results and Discussion

We restrict ourselves to the most significant effects, without presenting here the effects less or not significant (age, gender, educational level, etc.).
The PCA (Figure 1) performed using the 24 questions on the SE for 1454 teachers, shows a clear difference between French and Lebanese teachers.

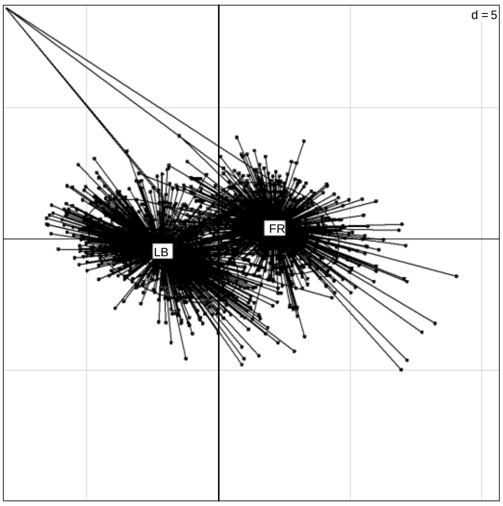

Figure 1a

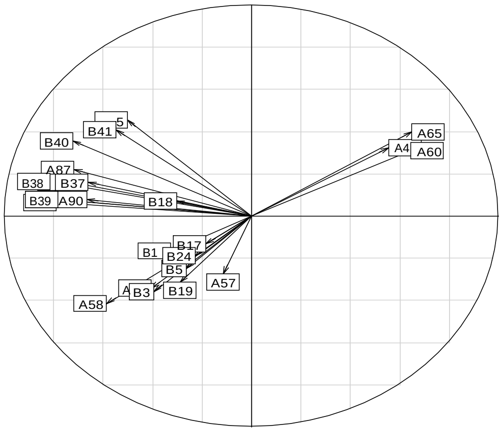

Figure 1b

Figure 1- (a) Individual points in the space for the first two discriminant axes differentiating the two countries as: FR = France, LB = Lebanon. **(b)** PCA on the SE variables (24 variables), France + Lebanon.

A between analysis, supplemented by a randomization test of Monte Carlo, shows that this difference is highly significant.

In fact, French teachers, unlike Lebanese teachers, are more conducive to early learning topics related to sexuality to students aged 6 and 15 years depending on the subject (A85 à A90 et B37 à B41). They are more likely to accept abortion (A65) and homosexuality (A41), to focus on safer sex as an attitude that can reduce the spread of AIDS (A60), and to consider that the teaching of STIs is not only the issue of biology teachers.

The analysis of the issues that most differentiate the two groups shows KVP interactions: Lebanese and French Teachers opposed or not to abortion, homosexuality, are in the same time more or less favorable to the introduction some scientific content (K) in the SE, based on their religious values (V) and their associated social practices (P).

The histogram in Figure 2a shows that while 52% of French teachers are for equal rights for homosexual and heterosexual couples, 72.3% of Lebanese teachers refuse such equality.

Homosexual couples should have the same rights as heterosexual couples.	I agree	1	2	3	4	I don't agree

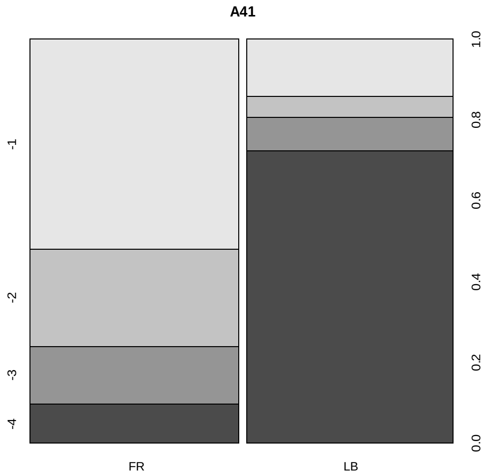

Figure 2a. Histogram of individual responses to question A41 (values 1, 2, 3, and 4 correspond to four levels of "Likert scale")

The histogram in Figure 2b shows that 71.2% of French teachers found that incest and sexual abuse are topics to be taught at an early age (the ages of 2 fields are added here), 60.8% of Lebanese teachers that are for late teaching of these topics (> 15 years) or never at school.

When do you think the following topics should be first introduced at school by teachers and/or external specialists? (Tick only ONE box per line):

Topic		Less than 6 years old	Between 6 and 11 years old	Between 12 and 15 years old	More than 15 years old	Never in school
B39.	Incest and sexual abuse	1	2	3	4	5

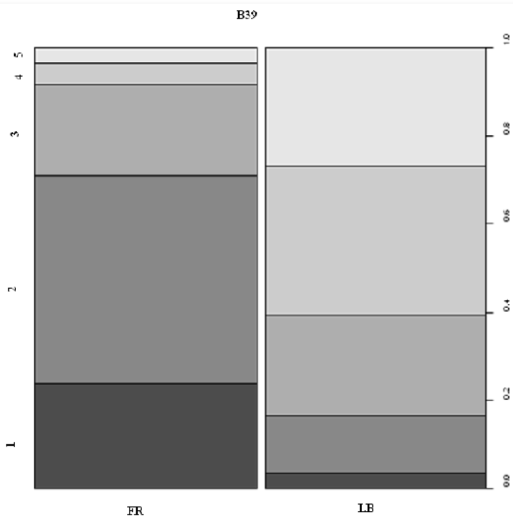

Figure 2b. Histogram of individual responses to question B39 (values 1, 2, 3, 4 and 5 correspond to five levels of "Likert scale")

The 1 454 teachers' conceptions also vary quite significantly depending on their religion, which is very different in the two countries: half of French teachers are atheists or agnostics, against 0.4% of Lebanese teachers interviewed, 65% of Lebanese teachers are Muslims (Shiites, Sunni or Druze) against 1.5% of French teachers interviewed. It is therefore not surprising that when we remove the country effect, the religion effect disappears. However, when we remove the religion effect, the country effect remains very significant, which means that Christian teachers (41.5% of the French sample, 30.1% of Lebanese teachers interviewed) have different ideas about human sexuality and its teaching (Figure 3).

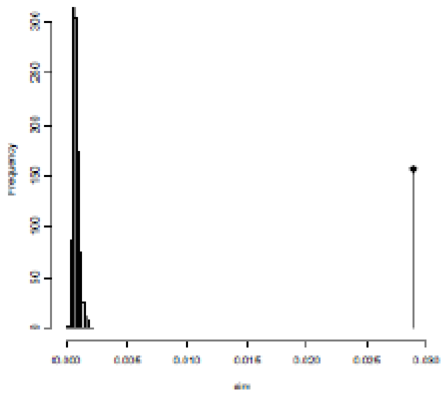

Figure 3. The test of randomization (Monte Carlo)

Finally, a co-inertia analysis between firstly a PCA on the SE variables (Figure 4a) and on the other hand a PCA on the socio-political and religious variables (Figure 4b) highlights two systems of conceptions: one characteristic of most believers and teachers practitioners, less secular (more against separation between politics and religion, hence between science and religion) are more detrimental to early education of the SE at school, less accepting of homosexuality and abortion, and they prefer stable relationships of couples to "safer sex". Most of the Lebanese teachers are in this pole. The second system of conceptions brings together teachers less religious, more secular, and more favorable to the SE in school; this pole includes the majority of the French teachers.

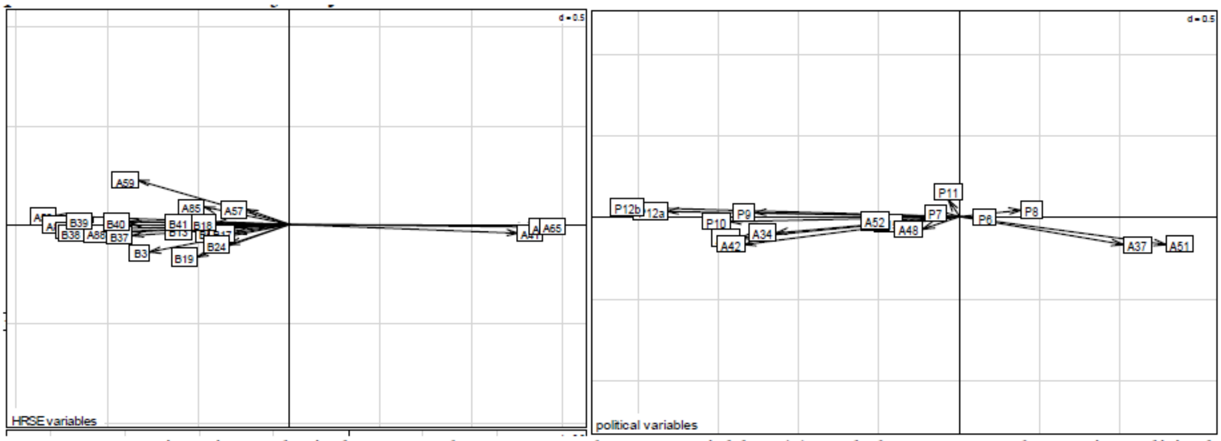

Figure 4- Co-inertia analysis between the PCA on the SE variables (a) and the PCA on the socio-political / religious variables (b).

5 – Conclusions

Beyond their religious diversity, the Lebanese teachers share ideas on human sexuality and SE, which distinguish them clearly from the French teachers. Each country has its own identity rooted in its specific geographical, historical, economic and cultural context. The relative homogeneity of the Lebanese teachers who has also emerged in comparing of their conceptions to those of teachers from other countries on topics such as evolution (Clément & Quessada 2008, 2009), or environment education (Khalil & al, 2007 a and b), explains the difficulties of implementing the SE in Lebanon. The perspectives opened by these results will be discussed in more details.

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PART 9: SCIENCE CURRICULUM, EDUCATIONAL POLICY

Co-editors: Jens Dolin and Miia Rannikmâe

Curriculum development. Reform implementation, dissemination and evaluation. International comparison studies such as TIMSS and PISA. Evaluation of schools and institutions. Policy and Practice issues: local, regional, national, or international issues of policy related to science education.

This part corresponds to strand 9. It contains 13 papers.

TABLE OF CONTENTS OF PART 9
SCIENCE CURRICULUM, EDUCATIONAL POLICY

THEMATIC CLASSIFICATION OF ELIGIBLE CONTEXTS FOR A HOLISTIC PERSPECTIVE IN CURRICULUM DEVELOPMENT

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Abstract: The goal of this study was categorizing the contexts according to disciplines as disciplinary, interdisciplinary or multi disciplinary. As a second goal we would like to figure out which contexts are mostly eligible for instruction and induces student interests. We designed a survey with 77 physics and chemistry contexts which were chosen systematically from high school physics and chemistry curriculums. The sample of this study was consisted of 104 pre-service student teachers from 3 different departments of the two universities in Ankara, Turkey. The determination contexts as perceived interdisciplinary and multidisciplinary can be used to design a holistic curriculum that unites many courses under the same theme. Determination of interesting contexts can be very helpful for course designers, textbook writers, teachers and educational researchers as a starting point. According to the descriptive data analyses for context discipline relationship, 77 contexts were categorized into four groups. These groups are mainly physics (44), mainly chemistry (18), both physics & chemistry (14), and other disciplines (1). The students' willingness to learn and to teach these contexts part comes out with two categories. Student teachers are equally willing to learn and teach 58 contexts and their willingness to learn was greater than to teach for 19 contexts.

Keywords: Curriculum Integration, Holistic Curriculum, Eligible Contexts, Context Based Education, Curriculum

Background, Framework, and Purpose

In the direction of the new reform trends in science education, elementary and secondary education curriculums were redesigned and disseminated by Turkish Ministry of Education. Both elementary and secondary curriculums are embraced constructivist principles, daily life activities, and multi-modes of assessment as possible as in the Turkish context (Elmas & Geban, 2010; Ozturk, Elmas & Savas, 2011). Among the others, high school physics curriculum is the one which uses context-based approach as one of its main perspectives. Context-based approach is very popular in the design framework of many reform curriculums and science projects. Salters' Chemistry, Salters' Science and Salters' Advance Chemistry 1989-1990-1992 in UK, Dutch PLON project in the Netherlands, Large Context Problem Approach in Canada, Applications-led approach in Scotland (UK), Event-centered learning in Brazil, and Chemistry in Context in Germany and the US are well known examples. The effectiveness of context-based approach in class instruction has been gathering evidence also from the literature (Bennett, Lubben, & Hogarth, 2005; Bennett, Grasel, Parchmann, & Waddington, 2007).

The success of context-based approach in school practice depends on teacher and student roles, classroom atmosphere, and students' connection with the contexts (Gilbert, Bulte, & Pilot, 2011). Students learn better when encountering contexts which support their cognitive structures in their minds. Meaningful learning occurs when contexts are enacted to the classroom instruction according to students' interests (Medrich, Calderon & Hoachlander, 2002). If the contexts presented in the instruction do not accompany with students' daily life experiences and interests, students cannot be focused to the inquiry process and lose their motivation (Conger, 2001).

Most of the researches are promoting the context-based approach but there are not many studies which fill the gap between students' interests and eligible contexts for effective classroom instruction in Turkey (Serin, 2009; Yaman, 2009; Sahin & Eryilmaz, 2010). In addition to determining the eligible contexts, using one as theme for integration of physical sciences or as a multi disciplinary way to connect many courses in the classroom instruction can be an effective way (Ioannidou & Banos, 2009). To employ one context, for integrating many disciplines in the same classes can empower students' cognitive structures in multiple perspectives about the same scientific phenomena. Focusing the real life problems without compartmentalizing the sciences into disciplines is the main principle of curriculum integration (Baykal, 2004). Beane (1995) defined the curriculum integration as;

> ''Curriculum integration is not simply an organizational device requiring cosmetic changes and realignments in lesson plans across various subject areas. Rather, it is a way of thinking about what schools are for, about the sources of the curriculum, and about the uses of knowledge.'' (p. 616)

Curriculum integration supports social meaning, technological aspects, scientific literacy, and public understanding of science (Beane, 1995). Probable four main benefits of the integrated curriculums are; holistic learning, relevancy to learners' life, development of problem solving skills, and supports Science-Technology-Society approach (Chan, 2005).

Curriculums characterized by strict disciplinary boundaries and without supporting the social and daily life aspects of students are coming to an end (Venville et al., 2002). The integration should not be artificial, arbitrary, abstract, or irrelevant to students' daily life (Aikenhead, 2003). Students do not relate their daily life issues to separated disciplines; they see the problems as a whole. What is important at this point is the how school science responds to students' needs and interests. Relevance of the contexts to what and to whom are the critical questions to clarify the issue (Mayoh & Knutton, 1997). Students, teachers, pre-service teachers and science educators are the crucial decision makers of determination of the relevant integration contexts in addition relevance to daily life and social issues are significant aspects. In this study, researchers attempted to determine the relevant contexts for integration with pre-service teachers as a first part of the study. The purpose of this study was to determine pre-service teachers' views about classification of the eligible contexts for integrated curriculum. Gender difference was also taken into consideration regarding the classification of contexts.

Rationale

Since the importance of the determining the interesting and eligible contexts, pre-service teachers are more ample to choose which contexts are more eligible for instruction for two reasons. Sometimes students' interest to an ineffective context really blocks the path to the meaningful learning of science. In addition, pre-service teachers are aware of the new educational trends and curriculum goals for more than high school students as. Classifying the contexts according to their relationships between disciplines and determining their position as a disciplinary, interdisciplinary or multidisciplinary context can be helpful for organizing a thematic curriculum from a holistic perspective. The determined multi disciplinary contexts may be seen as an inducer for a new holistic curriculum. Holistic curriculum can serve as a bridge to unite many courses and schools at the same time interval (Finch, Frantz, Mooney, & Aneke, 1997). Moreover, these appealing contexts can be easily used for teachers, textbook writers and educational researchers.

Methods

Survey, which was used in the research, was consisted of 77 physical science contexts. These 77 mix physics and chemistry contexts were chosen systematically from the high school physics curriculum, high school chemistry curriculum, and Salters' Advanced Chemistry textbooks. The goal of the survey is to capture the pre-service teachers' opinions over the discipline and context relation. The figure out the context discipline relation physics, chemistry, none and others are the options in the survey. Students were allowed to mark one or more options for each context. If a pre-service teacher marked first two options, this means that this person perceived this context is an interdisciplinary context related to physics and chemistry together. Marking physics, chemistry and others mean that this context might be a multi disciplinary one. This shows that this context has a capacity to be used as a topic in an integrated and holistic curriculum. It is also possible to use in textbooks, and activities.

In addition, the students' willingness to learn and to teach these contexts was measured according to a four level scale. The first version of survey was face validated by three science educators. After face validation, the survey was piloted with six students. The shape, organization and contexts of the survey were redesigned in a series of meetings. The sample of this study was consisted of 104 pre-service student teachers from three different departments of the two universities in Ankara. Physics, chemistry, and science pre-service teachers, who can be graduated in two years, were selected as participants for the study. The survey was applied in the classrooms by their regular instructors. There were no additional explanations made other than the written guidelines at the beginning of the survey in any class. The approximate application time of the survey was almost 15 minutes. After data cleaning and missing data analyses, descriptive and frequency analyses were done by the PASW.

Results

According to the descriptive data analyses, 77 contexts (Table 1) were categorized into four groups. In the first category, 44 contexts were perceived as related with mainly physics. However, meteors were also related with other disciplines, automobiles with both physics and chemistry. Moreover, gyroscopes context were left empty by a significant number of students. In the second category, 18 contexts were perceived as related with mainly chemistry. However, respiration and photosynthesis were also related with other disciplines. In the third category, 14 contexts were perceived as related with mainly both physics and chemistry. Ozone layer and dialyses were also related with chemistry alone. Moreover, oceans were also related with other disciplines. In the last category, DNA is the only context that is related to the others category.

The students' willingness to learn and to teach these contexts were marked as 0, 1, 2, and 3 for each item, independently. By dividing this range to four equal intervals, we get a. 0-0.75, b. 0.751-1.5, c. 1.51-2.25, and d. 2.251-3 intervals. We summarized the results into two categories. If the item means of students' willingness to learn and the item means of students' willingness to teach were the same, we put them in the first category. There are 58 contexts in this category. All contexts in this category were wanted to learn and teach in the high level (Interval c) except gyroscope context. The item mean of the gyroscope context is in Interval b. If the item means of students' willingness to learn were greater than item means of students' willingness to teach, we put them in the second category. There are 19 contexts in this category. All contexts in this category were wanted to learn in Interval d and teach in Interval c except washing machine and Saz (a Turkish folk music instrument) context. They want to learn in Interval c and teach in Interval b. In general, the students wanted to learn and teach science by using these contexts.

Table 1. "List of Given Contexts"

Light	Robbery Alarm	Automatic Door	LCD Television	Atmosphere
Detergent	Nuclear Plant	Getting X-ray	Sun batteries	Atomic bomb
Aurora	Train Rails	Frost	Processing of oil	Rechargeable Batteries
Generator	Twins Paradox	High-speed trains	Hair Dryer	Photocopying Machine
Adapters	Meteors	Human	Particle Accelerators	Detectors
Radio Waves	Mechanical weighing machine	Digital weighing machine	Elevator	Crane
Airbags	Rockets	Washing machine	Swing	Ferris wheel
Gyroscope	Boats	Tumbler	Yo-yo	Firework
Earthquake	Saz	Buffle	Speaker	Eclipses of Moon and Sun
Rear-view Mirrors	Rainbow	Fiber optic cables	Eyeglass	Radar
Dialyses	Lather	Toothpaste	Shampoos	Cars
Sunglasses	Cell Phone	Medical Drugs	DNA	Muscles
Bridges	Breathalyser (drunk meter)	Photosynthesis	The Oceans	Fuels
Artificial Sweeteners	Recycling	Fertilizer	Pesticides	Paints
Aircraft	Respiratory	Bleach	Ceramic	Soap
Stars	Ozone Layer			

According to analyses of the data regarding the gender: Table 2. displays the more prominent contexts for willing to learn column.

Table 2. "The Willingness to Learn the Concept According to Gender Difference"

Category	**Most wanted to learn**	**Less wanted to learn**
All	Particle accelerators, rainbow, rubber alarm and eyeglass lenses	Light and boat
Female	Particle accelerators, dialyses	Boat and crane
Male	Eyeclass lenses, Sun batteries	Light and soap

Conclusions and Implications

The contexts chosen from Turkish high school physics and chemistry curriculums were accepted by most of the pre-service physics, chemistry and science students. Fourteen (LCD television, nuclear plant, getting x-ray, atomic bomb, atmosphere, rechargeable batteries, human, rocket ship, firework, muscles, dialyses, recycling, oceans, and ozone layer) out of 77 contexts were perceived as interdisciplinary. Only ocean context were also perceived as multidisciplinary.

The pre-service teachers' willingness to learn and to teach most of the contexts was same but gender analyses reported some differences in preferences of some contexts. However, there are 19 contexts that they want to learn more than to teach. These are light, robbery alarm, LCD television, nuclear plant, getting x-ray, sun batteries, atomic bomb, high speed trains, rechargeable batteries, human, washing machine, earthquakes, saz, eclipse of sun and moon, rainbows, fiber optic cables, automobiles, cell phones, and recycling.

When the researchers explored the willingness to learn in terms of gender difference, there are four contexts which were wanted to learn more (Particle accelerators, dialyses, eyeglass lenses and sun batteries) and four other contexts which were wanted to learn less (Boat, crane, light and soap) than others. According to the results, researchers should be careful while choosing a context not to do a gender bias because willingness of learning contexts depends on gender. Additional studies might be designed to investigate the reasons why context preferences differ in terms of gender.

Asking students what to learn could be starting point of context-based instruction. Probably one of the best ways to minimize the number of contexts in all courses is to use the same context for different disciplines. We tried to find these contexts for physics and chemistry courses by asking questions to the pre-service teachers who are half student and half teachers.

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THE CHALLENGE OF GENERIC COMPETENCES TO SCIENCE EDUCATION

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Abstract: Since 2000 there has been pressure on education systems for develop in students a number of competences that are described as generic. This pressure stems from studies of the changing nature of work in the Knowledge Society that is now so dominant. The DeSeCo project identified a number of these competences, and listed them under the headings of *communicative, analytical* and *personal*. They include *thinking, creativity, communication skills, knowing how to learn, working in teams, adapting to change, and problem solving.* These competences pose a substantial challenge to the manner in which education as a whole, and science education in particular, has hitherto been generally conceived. It is now common to find their importance acknowledged in new formulation of the curriculum. The paper reviews a number of these curriculum documents and how they have tried to relate these competences to the teaching and learning of Science, a subject with its own very specific content for learning. It will be suggested that the challenge provides an opportunity for a reconstruction of the teaching and learning of science in schools that will increase its effectiveness for more students.

INTRODUCTION

In the flurry of national reports about Science for All in the 1980s, the Science Council of Canada was alone in presciently listing *"preparation for the world of work"* as one of the four aims to be given attention if a Science for All was to be achieved (Science Council of Canada, 1984). Soon after In England, the Royal Society for the Arts (RSA) (1986) promoted the notion of education for capabilities associated with the world of work. Neither of these challenges about preparing students for the world of work in science classes were responded to by science educators in these two countries or elsewhere in other countries.

In the 1990s the OECD reported on a series of studies of young persons' transition from school to work and of the world of work itself (OECD, 1996a&b, 2000). Bayliss (1998) likewise further reviewed the world of work for the RSA . Work in developed countries, it was argued, is changing *in kind, in the requirements for performance*, and *in the permanence of one's engagement.* These changes in the world of work and employment are driven by new forms of information (ICT), which increasingly make knowledge be the primary source of economic growth. "The Knowledge Society" is an epithet that aptly describes these fundamental changes

In the Knowledge Society there is a shift in the characteristics of what it means to know. Knowledge is dynamic, like a verb, *rather than static, like a noun.* Knowledge is about acting and doing to produce new things, *rather than being the storing of bits of established knowledge.*

Value in the Knowledge Society is associated with knowing how to learn, knowing how to keep on learning, knowing how to learn with others, and seeing possibilities for solutions to problems.

Fraser and Greenhalgh (2001) listed these generic learnings with this dynamic character as *equipping students to adapt to change, to generate new knowledge* and *continue to improve performance*). DeSeCo is an acronym associated with attempts to define and select competencies as new priorities for teaching and learning (Rychen & Salganik, 2003). Three broad types of competence – communicative, analytical, and personal have resulted.

Jane Gilbert (2005) in New Zealand has provided a helpful dialogic account of both the Knowledge Society and of its demands on schooling. She recognizes the gulf between its paradigm for knowledge and learning and the paradigm of traditional schooling. In seeking a compromise she argues that competences, like *thinking, communicating, investigating,* and *problem solving*, require a context. Furthermore, students need to know that every knowledge discipline is built on such competencies as active strategies. The traditional paradigm of schooling has overemphasized the static established knowledge of the disciplines and given too little attention to their competences as disciplinary strategies. Science education in particular, has emphasized acquiring a store of established knowledge, and knowing the right answer to questions with only one correct answer

This paper discusses the manner and extent to which the capability/competence challenge has been attended with respect to Science in recent curricular reforms and discussions in Australia, New Zealand and several European countries. Two sources have been used to assess the overall curricular response to the demand for capability education: –

- detailed curriculum statements from three Australian states – Tasmania, Victoria, and Queensland, and from the Australian Curriculum and Reporting Authority
- a detailed curriculum statement from New Zealand, and
- the responses of science education experts in five European countries to a short questionnaire (available from the author) about the competences/science curriculum issues in their countries..

CURRICULAR RESPONSES TO THE KNOWLEDGE SOCIETY

Australia

Despite the lack of any coherent national debate in Australia concerning the competency paradigm, each state and national curriculum project since 2000 has specifically included some of these generic competencies as a prominent feature of the intended learning.

Case 1. Tasmania

In Tasmania, as early as 2002, a framework for a new curriculum was provided consistings of five sets of Essential Learnings, ***Thinking, Communicating, Personal Futures, Social Responsibility*** and ***World Futures.*** (Tasmania Department of Education, 2002). It is of interest to note that the words, *science, technology* and *environment*, only occur in the sub-text of ***World Futures***, and not in the first three sets that most directly make links with the generic competences.

Although this framework went on to list as one of its *Principles* that the curriculum must focus on *understanding, deep knowing, rigour and depth,* words that are familiar in the traditional paradigm of subject knowledge, the priority for these was lost among other statements that were unfamiliar to science teachers and seemed to prioritise the radically new first four sets of Essential Learnings. The rapid decision to withdraw this curriculum and revise it to a more customary approach based on six subject areas is indicative of the difficulty to provide a comprehensible and practical link between a very bold statement of intent for the demands of the Knowledge Society and what existed, and was familiar, in familiar subject knowledge-based schooling (Tasmania Department of Education, 2004)..

This revised curriculum in Tasmania stated that through all the curriculum subject areas students will learn to *reason, ask questions, make decisions and solve problems, communicate, create and convey ideas effectively and confidently, develop responsibility in the community, and understand and apply important concepts, knowledge and skills. Thinking* is 'to lie at the heart of the curriculum, and is an important goal of a balanced and quality education. Every teacher is a teacher of thinking. The skills of thinking are best taught explicitly, using the content, skills, and processes of the subject area'. However, in the revised statement for Science the word, "thinking" does not occur, a striking difference from the five other subject areas and ICT , which all specifically indicate how various thinking skills can be taught.

Case 2. Victoria
The language of Tasmania's curriculum initiative - *values, purposes, and principles* - find echoes in the Introduction to the **Victorian Essential Learning Standards, VELS,** (Victorian Curriculum and Assessment Authority,, 2007)**.** This curriculum is set out as consisting of just three connected strands of learning (schematically suggested as intertwining): **Physical, Personal and Social Learning, Discipline-based Learning** (Science is one of the six listed**),** and **Interdisciplinary Learning**

A number of Generic competences are listed under **Personal and Social Learning** while *Thinking* and *Communication* are subheadings under **Interdisciplinary Learning**.

In the **Discipline-based Learning** strand the essential knowledge, skills, and behaviours for Science are spelt out for each year level under two headings, familiar internationally for Science from at least from the early 1990s, as *Science knowledge and understanding* and *Science at work*. Under these headings none of the generic competences in the other strands are mentioned. Thus, as far as Science is concerned the intended *connectedness* of the three strands is thus almost invisible in this curriculum. Conversely, the Learning focus and Standards for **Personal and Social Learning** intend a rich variety of personal leaning, but without any direct reference to the corresponding content for learning at these levels in the **Discipline-based Learning** strand.

Case 3. Queensland
The preamble to **Learning P-12** commits this curriculum to develop three learning goals: *a solid foundation in knowledge, skills and values, an ability to create new ideas and translate them into practical application* and *generic capabilities that underpin flexible and analytical thinking, a capacity to work with others and an ability to move across subject disciplines to develop new expertise*' (Queensland Studies Authority, 2010)

Queensland uses syllabuses and guidelines to identify the content standards or required learning that is expected of students. Science is a Key learning area in Years 1-10. Assessment standards are the responsibility of teachers who are assisted by an Assessment Bank and the Queensland Comparable Assessment Tasks (QCATs) in Years 4, 6 and 9.

The introduction to Science refers to ‘the study of science helping to promote students’ personal attributes such as *perseverance, cooperation, collaboration and creativity* and *engages students in distinctive ways of thinking about and explaining events and phenomena.*

The essential learnings for science are set out under *Ways of Working* and *Knowledge and Understanding* which has a sub-heading *Science as Human Endeavour*. In the details for each year level there are explicit references to this list of generic competences, but they all come under the *Ways of Working* strand, and are not identified in, or associated with, the *Knowledge and Understanding strand.*

Case 4. Australian National Curriculum

In 2007 the new national Labor government announced the development of a national curriculum – a first for Australia with its federation of states holding the responsibility for school education. Consistent with origins in the earlier **National Declaration on Educational Goals for Young Australians** the abilities *to think flexibly, to communicate well* and *to work in teams* were to be included (ref),

In an initial document, *the Australian National Curriculum's Design*, the Australian Curriculum and Reporting Authority (ACARA) stated that schools will help students develop seven important general capabilities. These were listed as:

- *literacy,*
- *numeracy,*
- *information and communication technology (ICT) competence*
- *critical and creative thinking*
- *personal and social competence*
- *ethical behaviour*
- *intercultural understanding.,*

Brief descriptions were provided of what these capabilities meant in practice and of their importance.. The *Design* also suggests that *"some of these capabilities become more discipline-specific as the school years progress and that each capability will be represented in each learning area in ways appropriate to that area"*. In addition there was reference to what seemed to be other capabilities such as *to innovate, to solve problems* and *to engage with new disciplines (Australian Curriculum and Reporting Authority,2009).*

ACARA's Overview statement for this curriculum states that the general capabilities are to be embedded within the details of the learning areas, initially approved in 2010. The details for Science are set out in three stands, *Science as understanding, Science as Human Endeavour* and *Science as Inquiry.* The embedding has been done for each year of compulsory schooling (1-10) by associating the detailed topics in the three strands for Science in each year of schooling (1-10) in the 2010 document with one or more symbols that represent the different seven capabilities (Australian Curriculum and Reporting Authority, 2011). This association is best described as a "sprinkling on", since there is no rewriting of the learning topic to indicate how, say, *numeracy* or *personal and social capability, etc.* is to be included in the topic's teaching. Furthermore, In some years of Science not all seven symbols appear and conversely some topics that have apparent potential for including a capability are left unsprinkled.. The intention for a progression in the learning of the capabilities seems to have been subsumed as a lesser priority to the existing progression set out for the Science content. As a result the general capabilities become, at best, extra "stuff" to include in an already crowded curriculum.

New Zealand
Case 5. Given the greater degree of national debate about the Knowledge Wave in New Zealand it is not surprising to find that country's new curriculum in 2007 lists *thinking, using language, symbols, and texts, managing self, relating to others,* and *participating and contributing,* as five Key Competence intentions (New Zealand Ministry of education, 2007).

However, in the detailed statements for Science, as an identified *Learning Area*, the role of these competences, is much less clear. At most, they are subsumed under a strand entitled *Nature of science* which is intended to be "overarching and unifying". The wording of this strand reads like a classical statement of the epistemological characteristics of Science. *'Science leads to understanding about the world, it involves particular skills and methods, is durable, and is re-evaluated in the light of new evidence. Science is a socially useful knowledge system, has its own means of communication, and scientific knowledge can be the basis for societal decision making.'*

This strand in the Science statements is to be used to 'overarch and unify' the content knowledge learnt in the four traditional science disciplinary areas, but how this overarching and unifying is to be achieved is not indicated. There is no reference in the Science statements to any of the five competences heralded as the Key Competencies for this new curriculum..

Case 6 Switzerland
Eight science skills that are familiar within science are listed. When combined with specific science knowledge content they become scientific competences (relatable to the generic competences) for inclusion in the teaching of science.

to show interest and be curious	*to ask questions and investigate*
to exploit information services	*to organize, structure and model*
to assess and judge	*to develop and realize*
to communicate and exchange views	*to work self reliantly and reflect*

Case 7 England and Wales
There is general reference to competences, but no consideration of their progression in the the curriculum or their assessment. Currently, the national priority is on the content knowledge in Science, although assessment instruments are requiring some longer answers that could encourage the development of *communication skills* and *the argumentation skills* associated with critical thinking about science.
Case 8 Germany
The curriculum framework documents in many of the states contain generic competences as goals of education, and in some the need to link them with subjects is stated but not in specific detail. Where Science is concerned, the competences of *scientific methods, scientific communication* and *socio scientific reflection* have been identified. Scientific communication is more than prose answers. It is to involve students in reflecting on the appropriate means for explaining scientific phenomena to someone else.

Case 9 Sweden
The aims of the new curriculum for the science include reference to *curiosity and asking questions*, *critical thinking (*about their own results, the arguments of others and different information sources), and *interpretation and production of science content in a variety of texts* (that can make use of different forms of aesthetic expression),

Discussion

The Curriculum as a whole

Each new major curriculum in Australia and New Zealand since 2000 has stated quite explicitly that some of these generic competencies are to be prominent features of the overall intended learning. In Sweden and in some German states there is also explicit reference to a number of similar competences. In Switzerland, England and Wales there is affirmation in curriculum discussions and reports of the importance of these competences, but they are less clearly associated with the subject curricula, where disciplinary content is clearly the current priority.

Only in Australia and Switzerland has there been an attempt to detail the progression of the generic competences through the stages of schooling.

The relation between Competences and the Science Curriculum

The ways in which the five different curriculum statements suggest Competence education should be related to Science education can be described as *Priority to Generic Competences, Unconstructed Relation*, *Overlayed Generic Competences,* and *Competences Reconstructed for Science* (see Table 1).

Priority to Generic Competences	Unconstructed Relation	Overlayed Generic Competences	Competences Reconstructed for Science
Tasmania, 2002 (ACARA, 2011)*	Victoria, 2006, Tasmania, 2004	Australia, 2011	Switzerland, New Zealand, Sweden, Germany

Table 1. Relations between Competency education and Science education

*It is of interest to note that early in 2011 ACARA developed a draft document on the generic capabilities that raised their inclusion in the national curriculum to a possible new level. Each capability is introduced with a Description and Rationale, and then listed as sub-capabilities for single or combined year levels . For Science this approach led to at least 80 opportunities for student activity for each 2 year stage. It, in effect, led to an alternative statement of intended learnings in science that prioritized the capabilities rather than the science. This approach was discontinued and In the final statement of for *Science* the simpler but vaguer approach of sprinkling symbols of the capabilities was used as described above in Case 4.

The expert reports from Finland, and England and Wales suggest that at this point of discussion there is an *Unconstructured Relation*, but those from Switzerland, Germany and Sweden indicate positions closer to the category, *Competences Reconstructed for Science.*

Gilbert's (2005) above concern that the demands of the Knowledge Wave would place too great an emphasis in curricular responses on skills to the detriment of knowledge now seems premature in the light of actual or possible developments since that time. Traditional science knowledge still dominates in each curriculum. Concern can, however, be expressed that those responsible for Science have not seized the opportunity presented by the competence demand to sufficiently re-consider in what ways it could benefit science education. In other words, how could the teaching science also include the active learning the competence movement advocates.

Such a reconstruction could start by preceding each competence with the disciplinary adjective, 'scientific'. At least two models are available for incorporating these in mainstream curricula for Science, thus establishing their place in category, *Competences Reconstructed for Science*, in Table 1.

The first model is the PISA Framework for science. The essential components are real world S&T contexts, scientific competences that involve both knowledge of science and knowledge about science (OECD, 2006).Since this framework is not intended for a whole curriculum about whether traditional science knowledge or scientific competences has priority. It simply indicates that the latter when included as a focus in a science curriculum requires context to betaken seriously if they are to have meaning.

The second model has been used by Labudde et al (2007) in the HamoS project in Switzerland. It is a three dimensional model with horizontal axes representing *the knowledge domain of the sciences*, and *a set of "skill" practices* (practical and intellectual that are used within science). The vertical axis is *years of schooling.* The priority for teaching and learning are the intersections where these skills are interacted with domain knowledge, that is, *a set of scientific competences*. The skills in the case of Switzerland are the eight listed above in Case 6..

Finally, there is now a rich literature of research studies on the teaching of scientific competences. More than two decades ago researchers in science education in many countries began to explore answers to the question, *What are scientific competences?* and *How can these be taught and learnt?* Ohlsson (1995) pointed out that each of *describing, explaining, predicting, defining, arguing, critiquing,* and *explicating* are epistemic for science thinking, and the classroom studies of some of these have now been well reported. That this research has been so weakly drawn upon by 21st C curriculum decision makers sharply questions whether their goal is about improved learning of science or about balancing the interests of other stakeholders that do not include the students.

A final point
One reason why science curriculum developers have found the question about scientific competences so difficult may be indicated by the fact that ***thinking*** is not present in the list of 61 metacognitive and metalinguistic verbs used in official science curriculum documents (Wilson, 1999). Despite a lot of effort and resources going into the production of the five curricula discussed, alas, a science curriculum that has *Science as a Way of Thinking* as an clearly articulated emphasis alongside S*cience as a Way of Knowing* is still some way off.

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THE SPUTNIK REACHES ARGENTINA: THE CURRICULAR REFORM IN CHEMISTRY TEACHING (1956-1983)

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Abstract: This paper attempts to reconstitute the introduction of Sputnik's reform in chemistry teaching in Argentina between 1956 and 1983. Based on several sources of historic data and taking into account the social and cultural contexts in which the knowledge about curricular innovation has passed through, I try to understand how a particular educational system processes a worldwide curricular reform. For that, I start from the presumption that the Argentinean reform is more than a simple transferring or importation of exogenous ideas and knowledge, but the result of their local interpretation. In this case, a net involving the scientific professional field, the educational state bureaucracy and multilateral organizations, such as OAS, produced a curricular reform towards the modernization of academic subjects that was slowly introduced and filtered by a settled scholar culture assuring the continuance of descriptive characters in chemistry teaching, particularly in relation to organic chemistry.

Keywords: chemistry teaching, curricular reform, Sputnik.

INTRODUCTION

The teaching of chemistry at schools, like other natural sciences, has undergone a transformation between 1960 and 1970, representing an unstoppable wave of renovation. The history of this curriculum reform has been told from different perspectives and with different purposes, often in studies that prioritize the national cases (Atkin, Black, 2003; Chassot, 2004; Rudolph, 2002). The changes in both curriculum and practices of science teaching throughout Latin America in this period are usually associated to the renovation movement that has its origins in the United States and was known as Sputnik reform, in a reference to the Soviet satellite launched to the space in 1957 - an icon of the space racing between Soviet Union and United States (Chassot, 2004; Merino, 1987). In the case of Argentina in particular there is a remarkable absence of studies to think over this curriculum transformation. This article seeks to contribute to cover, partly, this gap, directing its main question to the process of introduction of the reform in this country, specifically in the case of chemistry.

THEORETICAL FRAMEWORK

By studying a reform or a curricular innovation is important to take into account that the introduction of these school devices is never an exact transfer or a relocation of knowledge and ideas from one country to another, because these processes of change always involve local interpretations, resistances and confrontations that will subvert the original ideas. For some curricular and reform theories, it is important to understand how a particular national education system incorporates a worldwide reform to produce a "curricular standardization", acting like a "social refraction" to the global changes forces, as well as the tension among changes and continuance that follows any educational reform (Benavot et al., 1991; Goodson, 2008; Viñao, 2002). Furthermore, according to curriculum theory, decisions involving curriculum cannot be understood isolated from the contexts of economics, politics and ideology that characterize the larger society (Moreira, 2009).

This paper focuses on the introduction of changes into the curricular and practices of chemistry teaching at high schools in Argentina between 1956 and 1983 and its relationship with the American reform. It is implicit in this work that the historical knowledge can provide us with a better understanding of the current educational practices as well as the constant demands for reforms in scientific education. To approach this historic object, the study of the history of education recommends that, besides pedagogic doctrines, its authors and development, we should analyze the social and cultural contexts in which these ideas have taken place and eventually acquired some autonomy. The diversification of sources (documents, textbooks, syllabuses, interviews) is essential to unscramble the actual scenario, including its stabilities and ruptures.

METHODS

This article covers the period between 1956 and 1983 whose boundaries correspond to the fall of the first Perón government and the democratization process that ending the last authoritarian government, respectively. The beginning coincides with the developmental step and with the Argentinean "scientific spring", when occurs the creation of the National Research Council – CONICET (Cereijido, 2000). This research covers a period that includes governments of different ideologies and that switches democracy with military dictatorships, whose attitudes towards science and academic communities can be a stimulus or hostility and even violent persecution of their representants. This period is characterized by the presence of pedagogical ideals of modernization, based on educational planning and technology, whose premises are being questioned after 1983.

By approaching the Sputnik Reform in the Argentinean case, we are using methods and techniques originated in the field of research of the history of education, which include documentary research in archives, reading, classification and interpretation of different sources for the reconstruction of historic processes. Helpful in this case is the documentation from national and international conferences and symposia about chemistry teaching that occurred in the period mentioned above. Besides that, the chemistry textbooks can be used to trace the reform in a level more local and near to school teaching practices. Some personal testimonies helped me to collect information about the path of this reform, identifying important actors and institutions which were involved in the reform. For elaborating models of analysis and interpretation, some concepts used were from social studies of curriculum but also from more specific studies about chemistry curriculum (De Vos et. al., 2002; Goodson, 2008).

RESULTS AND DISCUSSION

During the second half of the fifties, the ideas about economic and social progress in Argentina were deeply attached to the development theory. According to this theory, the less developed countries should import capitals – both financial and cultural – in order to speed up their development. Therefore, social institutions like schools should be transformed by copying the models from developed countries such as United States. At the same time, Argentina tried to organize and encourage the scientific and technologic knowledge into the society, since they are supposed to play a key role in progress. In 1958, the government created a national council to the promotion of science and technology, CONICET. Moreover, the human capital theory which strongly associated the social and economic development with the investments in education reached the Latin America through several international conferences sponsored by multilateral organizations like UNESCO and OAS – Organization of American States, in the 60's. On the other hand, Argentina was highly differentiated from most of poor Latin countries once it had a consolidated educational system and low levels of illiteracy. Furthermore, the Argentinean citizens could celebrate one Nobel Prize in Physiology that would be followed by other two prizes in sciences a few years later.

The secondary schools in Argentina were also facing a fast expansion by that time and they had just introduced different modalities of technical and professional schools. Nonetheless, its curricular organization model and orientation for college studies were still the same of that from the beginning of the century (Dussel, 1994).

The syllabus of chemistry in 1956 (which would remain unchanged until 1978) is almost the same of 1901, when it had been divided into inorganic and organic chemistry in a two-year course. Most of textbooks were written in two volumes, being the first dedicated to inorganic chemistry and the second to organic chemistry. The contents were essentially descriptive: in the first year, teachers were supposed to teach about water, salts, hydrochloric acid, halogens, nitrogen and carbon; while in the second year, they should teach about hydrocarbons, alcohols, aldehides and ketones, glucids, amins and amides.

Over the early sixties, the Department of Science Teaching from CONICET has attempted to improve the science teaching by "promoting its updating and efficacy in order to offer a solid scientific basic formation and encourage young students, awaking or developing their skills to the studies of science and research" (Hernaiz, 1967, p. 1). Their efforts were addressed to training courses for high schools teachers majored in chemistry, physics, biology and mathematics. One of the goals of these courses was to give a new pedagogic orientation to the sciences teaching based on an updated methodology, which would assure both the knowledge transmission and the proper conception of the scientific method (Hernaiz, op. cit.). These general aims were quite similar to those of the American projects of science teaching like CBA and CHEM Study.

At the same time, the OAS organized several inter-American conferences about natural sciences and mathematics in different Latin American countries. The First Conference of Chemistry Teaching, a partnership with the American National Foundation of Science (NFS), took place in Buenos Aires in 1965. Institutions like Ford Foundation, Nuffield Foundation, the OECD and UNESCO were present as observers. Interchanges among the participants of this conference helped spread the ideas about the American CHEM Study and CBA projects, as well as the Nuffield Project from United Kingdom.

In 1968, the First National Symposium of Science Teaching occurred in the city of Cordoba. Its recommendations included the common objectives of science teaching and the specific objectives of chemistry teaching to be achieved by the Argentinean educational system. This initiative was followed by the First Meeting about Chemistry Teaching in San Luis, during November of 1970. These events, that occurred outside the federal capital, brought the reform in the science teaching to the inner parts of the country, trying to reach more teachers and persuade them to incorporate "the imperative necessity of updating the methods and contents to address properly all the scientific-technologic requirements of our times in this area, similarly to that occurred in other experimental sciences" (Guerrero, Bonelli, 1973, p. 3). But for that, a long way should yet be paced.

In this moment, the promotion of these changes had left the CONICET scope and was in charge of the new National Institution to the Improvement of Science Teaching - INEC – coordinated by the National Bureau of Education and Culture. The INEC recruited some academic professors from the University of Buenos Aires and the University of La Plata to act around the country as subjects to facilitate the updating of the chemistry teaching in the secondary schools (Argentina, 1972). With the sponsors of the OAS, the INEC followed one of the recommendations of the First inter-American Conference of Chemistry Teaching by promoting a course to in-service teachers about the new curriculum. Supported by the Bureau of Education, the INEC developed the "Proyecto 30", which begins to be applied, experimentally, in 1970 within the 4th and 5th years of some schools in the capital and provinces. The Proyecto 30 followed a structure of topic units that included modern chemistry theories and it was increasingly applied to a broader audience being its results evaluated until 1978. Based on it, the Bureau of Education incorporated new chemistry contents into the last two years of secondary school in 1978, to be obeyed from the next year on. The 14th edition of Héctor Sirventi´s textbook, a very popular chemistry textbook during the 70's, stated in its foreword that "the development of subjects meets all demands from Proyecto 30, nationally applied from 1979 on". According to the author, the new contents correspond to the project's recommendations. The previous division of chemistry into a two-year school course now is simply named Chemistry I and Chemistry II, where the first one encompasses General and Inorganic Chemistry, and its subjects are atomic structure, equilibrium and kinetics, while Chemistry II is nearly the same Organic Chemistry of the earlier curriculum.

In 1972, the UNESCO organized a Seminar about chemistry teaching in Montevideo, Uruguay. In this seminar were presented and discussed the contents of the syllabuses developed in the Proyecto 30. Professor Ariel Guerrero, chairman of this Seminar and main coordinator of Proyecto 30 made some considerations about the set of contents. For him, for example, some contents of Chemistry I like reaction mechanisms, isotopic tracers and complexes can be teached during Chemistry II. In his words, the contents constitutes "(…) a maximum, which offers a complex landscape of the chemistry since a fundamental point of view, with applications in the everyday life with the biologic and technologic, and that catches the student interest" (Actas Seminario UNESCO, p. 176, 1972). He also adverted that the separation in Inorganic and Organic Chemistry has just a pedagogic sense and it doesn´t represent "a cisma" in the chemistry, once the reaction mechanisms and chemical bonding constitute the unifying principles between both. Guerrero considers that the teacher may, at its discretion, waive topics that he thinks unnecessary or inaccessible. Nevertheless, it is preferable to teach all issues, as it is to present "a broad overview of chemistry" and, at same time, by applying the scientific method in its continuous cycle: "(…) formulating hypothesis, planning experiments; observing, measuring, interpreting…so it is advisable shorten many issues rather than eliminate them." (Actas Seminario UNESCO, 1972). In 1978, when the Bureau of Education approved the new syllabuses for the high school, it considers that these contents "show and meet the methodological approach recommended by the renewing of curricula in chemistry at the secondary level in all international conferences about it".

In the new syllabus of Chemistry I, General and Inorganic Chemistry replaces the old Inorganic Chemistry and its setting of contents follows those proposed by the American project CHEMStudy. In that way it is possible to understand what the Department of Secondary School had told about the Proyecto 30, which methodological approach had been put to the test during international conferences, in one of the mechanisms to produce educational isomorphism associated to the school curriculum (Dale, 2007). Notwithstanding, the new syllabuses keep the division between Inorganic Chemistry – now incorporating General Chemistry - and Organic Chemistry: although such division doesn´t represent the “cisma” to be avoided, it mirrors the survival of the disciplinar code of chemisty in the Argentinean curriculum (Santos, Porro, 2008). The continuance of this division will be feasible because it has adapted quite well to the technology of curricular organization, which distributes the contents of chemistry by two years since the beginning of the XX century. It also means the triumph of curriculum survey (De Vos et. al., 2002). At same time, this continuance allows the survival of the descriptive chemistry: this old feature of the chemistry´s syllabus will find a place exactly in Organic Chemistry and in the teaching of all its functions. By keeping this division, Guerrero and his co-workers look like want to ensure the complicity of teachers, leaving one disciplinary structure from the beginning of the century untouched.

CONCLUSIONS

According to Fumagalli (1999), the projects of curricular innovation and theoretic discussions about science teaching produced in United States and other central countries constituted the reference marks since Argentinean educators rethink the questions about science education in this country during the Sputnik reform. However, their influence over teaching practices was lean and it was confined to small circles of educators. But in the United States, the science teaching reform aimed to modify a curriculum filled up with progressive ideology, whose contents highlighted household technologies, towards a new model focused on the logic structure of sciences and the underlying construction of the scientific knowledge (DeBoer, 1991; Rudolph, 2002). In Argentina, a settled school culture assured the stability of a curricular structure organized in the beginning of the century, based on the division of academic sciences and thereby the descriptive features of contents remained throughout the organic chemistry taught in Chemistry II. The strictly centralized educational system in Argentina, with a national curriculum to be followed by all schools and organized by the state, demanded a long time up to the introduction of changes and the modernization of chemistry teaching. Argentinean scientists, differently from their American colleagues, were not involved in curricular issues, leaving this task to those professionals that agreed to follow the state bureaucracy and accepted the foreign influences from organizations such as OAS and UNESCO.

In an article that asks about the research and the future of chemical education John K. Gilbert and co-workers (2002) consider remarkable the fact that, despite huge differences between countries and cultures, the chemistry curriculum in all teaching levels be so similar around the world. The history of the introduction of Sputnik Reform in Argentina can display some clues to understand this convergence. Also it is possible through this study to determine the ways by which some continuances found their places in the new curricula.

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BETWEEN SCIENCE AND CITIZENSHIP EDUCATION, THE CASE OF TRANGENESIS IN THE FRENCH BIOLOGY SYLLABUSES.

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Abstract: Transgenesis keeps on moving out of laboratories and industries into the public arena in the form of therapies, drugs, food products. This research, part of a PhD, deals with the way the scientific, medical, industrial and citizenship transgenesis practices are integrated in the French secondary school (pupils aged from 11 to 18 years old) biology syllabuses. It aims at describing the content and the organisation chosen for this school subject, reduced to its syllabuses. Identify aims, tasks, knowledge, reference and their consistency should especially allow to clarify if this teaching is thought by this school subject as science education or citizenship education.
The syllabuses analysed correspond to the last complete group of syllabuses elaborated for the school subject, "life and Earth sciences" (1996-2002).
The results show that the knowledge selected refers in majority to scientific practices while the tasks and supports refer to medical and industrial practices. The aims are often dual scientific and citizenship. A dual consistency can be identified: a scientific and a citizenship one. But if the scientific one is explicit (explicit connections between scientific knowledge, scientific aim) it is rarely the case of the citizenship one (the citizenship aims are rarely connected explicitly to knowledge or task). It suggests citizenship aim for transgenesis is present but secondary for this subject school whose aim would be first of all to ensure science education.

Keywords: school subject, French biology syllabuses, transgenesis, science or citizenship education, curriculum

INTRODUCTION

This research deals with the way transgenesis practices are integrated in the formal curriculum. Biotechnologies, especially transgenesis, keep on moving out of laboratories and industries into the public arena in the form of therapies, drugs, food products. It has and will have impact on the lives of citizens. Thus, transgenesis is a matter for scientific, industrial, medical and citizen practices.
As suggested by Martinand (1986) each of these practices have its own consistency which find expression in its different characteristics (intellectual and material tools, problems, social parts, knowledge produced). For citizens, transgenesis raises various socio-scientific issues with regards, for example, to ethics, to the level of acceptable risk and to the usefulness of the new products. For scientists, industrials or doctors, it brings other questions into play.
Insofar as transgenesis is a matter for science and citizenship education, it raises the question of how the French school subject dedicated to life and Earth sciences ("les sciences de la vie et de la Terre" other named SVT) have taken charge of it.

FRAMEWORK : HOW TO DESCRIBE A SCHOOL SUBJECT ?

A school subject is a complex and original elaboration taking into account different logics (political, institutional, social, philosophical, didactical) both for its elaboration and its implementation (Chervel, 1998). Our study only deals with the formal school subject, limited to its syllabuses. Only the didactical logic underlying the syllabuses elaboration is questioned. It aims at describing the content chosen and their organisation.
From a study on technology as a school subject, Lebeaume (1999) put forward a theoretical framework to contribute to school subject intelligibility. A school subject can be defined by

constructive and founding principles. Clarify these principles comes to identify the choices made about aims, task and supports, knowledge, reference and the consistency of theses different choices with one another for the whole school subject. The choices are all the more consistent as they refer to the same practice. The more it is consistent, the more its should allow pupils to better understand the practice taken as a reference.

PURPOSE AND RATIONALE

Our purpose is therefore to identify which choices have been made by a school subject, reduced to its syllabuses, for transgenesis as far aims, tasks, knowledge, reference and their consistency are concerned in order especially to clarify if this teaching is thought by this school subject as science education or citizenship education.

The research questions are :

- which aims, content (knowledge, tasks and supports) and reference have been selected for the different syllabuses for the different levels and "sections"?
- to which degree, aims, content and references are consistent?

METHODS

Data’s collection

The corpus is constituted by the syllabuses elaborated between 1996 and 2003 which is the last group of syllabuses describing a complete formal schooling from 6ème to Terminale (pupils aged from 11 to 18 years old). A new curriculum is being elaborated nowadays but it is not yet complete.

To deal with the analysis of a complete curriculum (Paindorge, 2007), a table collecting the knowledge, the tasks and supports and the aims related to transgenesis has been elaborated from the official secondary school’s syllabuses.

Data’s analysis

Each knowledge unit and task is compared to a characterization of different transgenesis practices in order to suggest a reference. The scientific, citizen, medical, industrial transgenesis practices taken as a reference have been characterized a priori.

The consistency of the various choices at a specific grade and through the curriculum is examined by connecting the knowledge, the tasks and supports, the aims and the implicit references.

RESULTS

Aims, contents and references selected for the school subject's different syllabuses

Transgenesis is present in the school subject syllabuses at five grades (cf. Table 1)

Table 1: grade and title of the part including transgenesis

Collège (6e, 5e, 4e,3e) (pupils from 11 to 15 years old) (compulsory school)
3e : "Human responsability : health and environment "
Lycée (2nde, 1ere, Terminale) (pupils from 15 to 18 years old)
2nde : "Cell, DNA and the unity of the alive" + themes in the choice
1ere ES (economic section) and 1ere L (literature section) : from genotype to phenotype : biotechnologies applications **1e ES**: "A natural resource : wood"
T S (scientific section) : "From genetics start to biotechnologies current stakes" (this part including transgenesis concerns only students who have chosen biology as a speciality)

Scientific practices have been selected in majority as a reference for knowledge.

The transgenesis scientific foundation is often called to mind (2nde, 1e ES/L). Several transgenesis aims referring to industrial and medical practices are evocated and are often connected to scientific knowledge: protein productions (1eES/L, TS), genetically modified organism (GMO) construction (1ère ES and TS), genetic therapy (TS). The environmental impact is only approached once in 3e and refers to citizenship practices for it is connected to the idea of watchfulness towards biodiversity.

Medical and industrial practices have been selected in majority for tasks and supports.

Tasks and/or supports referring to transgenesis are proposed for almost all grades. The tasks and supports selected aim at studying transgenesis through different examples: GMO tolerant to pesticide (TS), improvement of quality for wood industries (1ère ES), production of drugs (1ère ES/L/TS). Only one task and support refer clearly to citizenship practice. They aim at studying transgenesis impact on the environment from the societal angle (by analysing documents dealing with the problems associated to plant GMO (TS)).

Scientific and citizenship aims are associated with transgenesis.

In 1e ES/L and TS, citizenship aims are closely associated with scientific aims: the reflexion must be based on scientific knowledge. In 3e and 2nde the aims are either citizenship (3e) either scientific (2nde).

Consistency of these choices

An example : analysis of the consistency of the choices for the part taught in 1eES/L : "From genotype to phenotype, biotechnologies applications".

The scientific aim (to understand the genetic information expression) and the knowledge (transgenesis lay on genetic code universality) referring to a scientific practice are consistent and refer both to science. On the other hand, the task referring to an industrial practice (production by transgenesis of drugs) and the citizenship aim (to tackle a critical reflexion on genomes studies and biotechnologies applications including transgenesis) are not clearly connected to anything in terms of reference. The main consistency is thus scientific. The task referring to industrial practices is in fact to the scientific aim's service. The industrial reference is hence hidden. At last, consistency between the citizenship aim, a reference to citizenship, the knowledge referring to science and the task referring to industry remains implicit in the syllabus. A citizenship consistency is thus possible but not explicit.

Transgenesis is for this syllabus, rather part of a science education than a citizenship education.

A dual consistency (scientific and citizenship) can be identified for the a majority of syllabuses. The explicit reference in syllabuses of knowledge (K), task (T), aim (A) to science (S) or citizenship (C) is indicated for the different grade in table 2.

Table 2 : explicit reference to science or citizenship of syllabuses' content and aims

Reference to	**3eme**	**2nde**	**1ere ES**	**1ere L**	**TS-speciality**
science		**KTA**	KA	**KA**	**KA**
citizenship	**KA**		A	**A**	**TA**

Table 2 shows that, for this school subject, the consistency thought in syllabuses is above all scientific : most of knowledge refers to scientific practices and are consistent to scientific aims. The citizenship consistency is always implicit except in 3e and TS where a knowledge (3e) or a task (TS) are referring to citizenship practice and can be explicitly connected to the citizenship aim.

CONCLUSION AND IMPLICATIONS

The knowledge selected refers in majority to scientific practices while the tasks and supports selected refer to medical and industrial practices. In this way, it appears that for transgenesis school subject is thought as original elaboration gathering elements taken from different practices. This raises the question of which image of these practices this school subject contributes to build. To which degree, this school subject reduced to its syllabuses allows to understand these practices, their different logics and stakes.

Furthermore, transgenesis is connected in the syllabuses to a genetic teaching which is part of a determinist vision of genetics especially in 3e and 2nde (Fuchs-Gallezot, 2009).

Otherwise, the aims are often dual scientific and citizenship. Citizenship taken as a reference is always a citizenship based on rationality (Tutiaux-Guyon, 2006). The point is to show how scientific knowledge could contribute to better understand different socioscientific issues.

A dual consistency can be identified: a scientific and a citizenship one. But if the scientific one is explicit (explicit connections between scientific knowledge, scientific aim) it is rarely the case of the citizenship one (the citizen aims are rarely connected explicitly to knowledge or task). It raises the question of the difficulty for teacher to identify in syllabuses the dual scientific/citizenship consistency and to implement such a complex organisation.
It suggests citizen aim for transgenesis is present but secondary for this subject school whose aim would be first of all to ensure science education.

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SCIENCE IN THE IRISH TRANSITION YEAR: THE PUPIL EXPERIENCE

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Abstract: This study is concerned with the Irish Transition Year Programme (TYP). The TYP is an optional year in the second level Irish education system, which falls between the junior cycle and senior cycle. The year is curriculum-free, allowing schools the autonomy to design their own curriculum and syllabi for the year. This study is part of a larger one which aims to investigate the place of science in this year. The study tried to achieve a holistic view of science in this year, and as such investigated science in Transition Year from the perspective of pupils, teachers and students. This paper presents some results from the pupil perspective, in particular examining the pupils' experiences of science in the year. Previous work has shown that teachers are not using the year to design their own curriculum, but are relying on the senior cycle science curricula. This study has indicated that the teaching methodologies used by the Transition Year science teachers are significantly different to those used in teaching junior cycle science. However, the results of this study indicate that this year has little impact on pupils, and many still choose not to take up science to senior cycle, particularly the physical sciences.

BACKGROUND, FRAMEWORK, AND PURPOSE

The Irish second level education is broken into two cycles: the junior cycle and the senior cycle. Both of these cycles culminate in a terminal state examination. Between the two cycles is a one year programme known as the Transition Year Programme (TYP). This programme is an optional one year programme, which schools are not obliged to offer and if offered, pupils are not obliged to take it (Department of Education 1993). The year was originally introduced in the1970s in recognition of:

- The need to encourage personal and social development;
- The right of all students to a six-year post-primary education;
- The fact that Irish children leave second level school at a younger age than their European counterparts;
- The failure rate at third level;
- Employment prospects at that time.

(Transition Year Second Level Support Service 2006)

These issues, which led to the introduction of the Transition Year, are currently still relevant to Irish pupils. Over the last 5 years over three-quarters of second level schools offer the TYP, and over half of pupils have taken the year. The TYP has long been hailed as a particularly innovative and unique year. To date no study has investigated how this curriculum-free year is being utilised in terms of science teaching. The TYP offers teachers a rare opportunity to teach science in a relevant, context-based manner, appropriate to their individual pupils. The Irish education system has been noted to be highly centralised and standardised and typically uses traditional, didactic teaching methods (Forfás 1999, p. 20, Smyth *et al.* 2004, p. 7). This study has evolved to address the lack of information currently available on the place of science within the TYP. This paper seeks to investigate the experiences of pupils taking science in the TYP.

METHODOLOGY

A number of research questions were developed in order to define the parameters of the study. The specific research questions to be answered in relation to the pupils' experiences of science in the Transition Year Programme are as follows:

- *What are pupils' experiences of science within the Transition Year?*
- *What impact, if any does taking Transition Year sciences have on pupils' decision to take a science subject at senior cycle?*

This study is part of a larger PhD study, utilising a dual methodological approach. A quantitative approach was taken for this element of the study, though the study as a whole incorporates a mixed method approach. A pupil questionnaire was developed both for pupils at the end of their TYP experience, and pupils at the end of their Junior Certificate science experience.. The questionnaire was designed to explore attitudes and feelings towards science. It also sought to identify how the science in the Transition Year was being utilised in the schools that offer the programme. A review of previous research conducted in the area of the Transition Year and Transition Year science provided the basis for the design of the instrument (Smith and Matthews 2000, OECD 2004, Smyth *et al.* 2004, Darmody and Smyth 2005, Regan 2005, Jeffers 2007, Childs *et al.* 2010, Matthews 2010, OECD 2010). Both questionnaires were designed in three sections. The three sections in the Transition Year pupil's questionnaire consisted of 'general information', 'Transition Year and Transition Year science', and 'subjects I plan on studying for my Leaving Certificate'. Similarly the Junior Certificate science pupil's questionnaire consisted of a section on 'general information', a section on 'the Junior Certificate and Junior Certificate science' and 'subjects I plan to study for my Leaving Certificate'.

In total 25 schools were selected which offered the TYP, and 5 schools which did not offer the TYP. These schools were randomly selected from two databases, one listing the schools which offer the TYP, and one listing the schools who did not offer the TYP. Both groups of pupils were at the same educational stage as they were about to move into the senior cycle. Schools were contacted by letter, which was followed up with a phone call in order to get agreement from the schools to take part in the study, and finally the questionnaire was sent to 21 schools who agreed to participate in the study. Of these 16 schools (3 non-TYP schools and 13 TYP schools) returned the questionnaires, giving a response rate of 71.4%. In total, 319 pupils responded throughout the 16 schools. The responses of these questionnaires were analysed using PASW (Predictive Analytics Software), version 17.0.

RESULTS

Two groups of pupils (N = 319) were surveyed in 2009 using the two different instruments described in the methodology. In the first group, the pupils surveyed (N = 277) were administered the questionnaire at the end of their Transition Year, and are attending a school which offers the Transition Year programme. Of the 277 TYP pupils surveyed 121 (43.7%) were male and 156 (56.3%) were female. Pupils' median age was 16 (n = 218, 78.7%), though a small percentage of the cohort were 15 (n = 36, 13.0%), and 17 (n = 22, 7.9%), with one pupil aged 19 (0.4%). The majority of pupils (33.3%) took the year because it was compulsory in their school; however, 21.8% of pupils took the year as they felt it would be an opportunity to mature, other (11.5%) felt the year would allow them a break from studying and the pressure of the standardised system. The second group of pupils (N = 42) were at the

end of their Junior Certificate programme in non-TYP schools. This group was the control group for comparison against the TYP group.
Science may be offered to pupils in a wide variety of formats in the Transition Year or it may not be offered at all. Science is not compulsory at any level in the Irish second level system including the TYP. Results show that 60.0% of Transition Year schools offer the physics in the TYP, 51.6% offer chemistry, and 64.4% offer biology and some offer a combined science taster (35.6%). When the TYP pupils were compared to the non-TYP pupils, there were no differences between their attitudes towards science. Both groups ranked science as their 5th favourite subject. There were also no marked differences between pupils' levels of enjoyment or interest of science. Overall, non-TYP pupils were more positive about their experiences of junior cycle science, in comparison to the TYP pupils' retrospective look at their experiences of the subject. This was not a significant difference. However, there were differences in how the subject appeared to be taught. The tasks in the TYP were significantly different ($p < 0.05$) to those that non-TYP pupils completed in their science classes. Junior Certificate science appeared to consist mainly of 'traditional' activities such as reading, answering questions from and writing in their science book, doing calculations and having regular written and oral tests. TYP pupils spent more time taking part in group work, having pupil presentations and visiting speakers, using the computer and internet, and entering science competitions. As to whether the TYP influenced the uptake of science subjects to senior cycle, a significant number of non-TYP schools did not offer physics or chemistry and there was little difference between the percentages of students who took these subjects. However, a significant number of pupils coming from the TYP schools chose to take biology, which was offered at senior cycle in all schools.
A wide variety of subjects were offered to the pupils in the TYP. Figure 1 illustrates the subjects that were offered to the pupils. It is worth noting that while a wide variety of subjects were offered to pupils, the subjects were not offered uniformly to pupils.

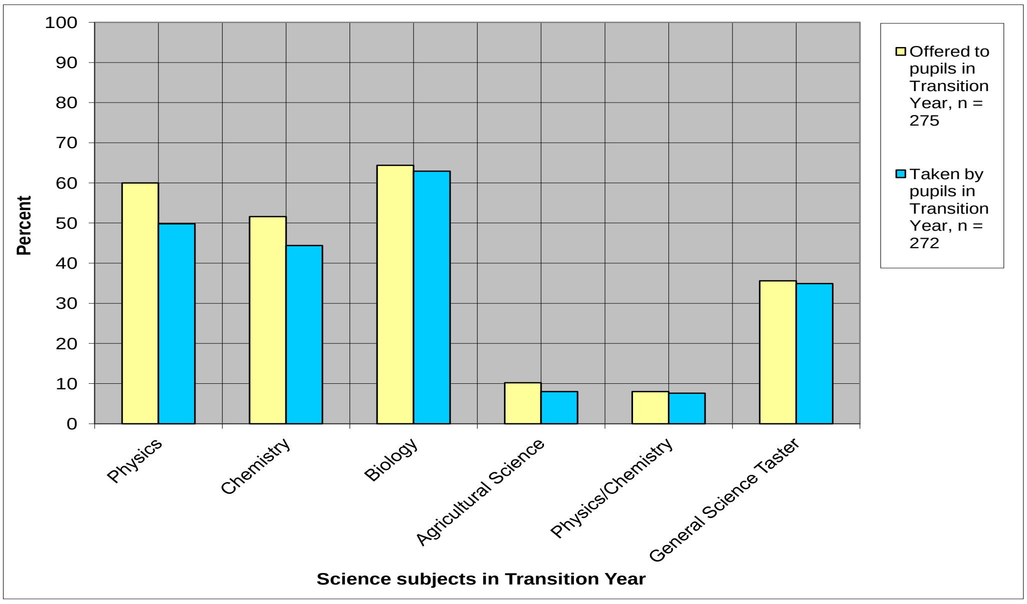

Figure 1: The science subjects offered to and taken by TYP pupils.

As illustrated in Figures 1, there is a significant mismatch ($p < 0.001$) between the science subjects offered in the TYP and those taken by the pupils.
The number of practical classes per week in TYP science classes was examined. Although most pupils have one or more practical science classes per week, 15.8% of pupils have either no practical classes or less than one per week.

The study also investigated the range of activities that pupils were experiencing in their TYP science classroom, and compared this to a more traditional Junior Certificate science class.

In line with Transition Year guidelines, pupils rarely or never do activities such as writing in (43.8 %) or answering questions from (77.9%) their science text book, or reading from it (74.6%). Practical activities, such as working with apparatus or materials (82.3%), carrying out experiments (83.8%), doing project (75.1%) and group work (91.6%) were all experienced often or sometimes by pupils. However, activities central to the development of communication skills, scientific literacy and critical thinking in science, such as having pupil presentations (66.2%), debates (83.0%) and taking part in activities such as the BT Young Scientist, SciFest or Science Fairs (63.2%) were all experienced rarely or never. Activities, such as visiting scientific industry (80.8%), going on field trips (80.8%), listening to visiting speakers (60.5%), or attending seminars (83.6%), which would allow pupils more insight into the everyday contexts and the various types of science-related jobs, were also rarely or never experienced.
However, when the TYP pupils' experiences of the frequency of these activities were compared with the non-TYP pupils, using Chi square testing, some significant differences were noticed as indicated in Table 1 below.

Table 1: The differences between non-TYP and TYP pupils in the frequency of activities in science class.

Type of Activity	p-value	Pupils who experiences the activities most frequently
Writing in your science workbook/practical copy	0.001***	Non-TYP
Answering questions from your science text book	0.000***	Non-TYP
Listening to the teacher talk about topics	0.496	Non-TYP
Reading from a science text book	0.000***	Non-TYP
Having discussions about science	0.806	TYP
Watching the teacher use apparatus to demonstrate ideas	0.583	TYP
Working yourself with apparatus/materials	0.016*	TYP
Doing calculations	0.001***	Junior Certificate
Carrying out experiments	0.075	TYP
Doing project work	0.239	TYP
Doing group work	0.000***	TYP
Having pupil presentations	0.003**	TYP
Having debates	0.280	TYP
Watching T.V./DVDs/Videos on scientific phenomena	0.000***	TYP
Using a computer	0.000***	TYP
Using the internet	0.000***	TYP
Going on field trips	0.001***	Non-TYP
Visiting industry or scientific businesses	0.177	Non-TYP
Listening to visiting speakers	0.001***	TYP
Attending seminars	0.284	Non-TYP
Having written tests	0.000***	Non-TYP
Having oral tests	0.000***	Non-TYP
Work Experience	n/a	n/a
Taking part in activities such as SciFest, BT Young Scientist, Science Fairs etc.	0.000***	TYP

Significance levels: *p< 0.05, ** p<0.01, ***p<0.001

The data in Table 1 clearly indicates that non-TYP pupils experience more traditional activities in their science classes. TYP pupils appear to have their science classes more supplemented with access to resources and slightly less traditional teaching and learning techniques. Traditional assessment techniques are also experienced less frequently by TYP pupils. TYP pupils have significantly more experiences of general practical activities, when compared to the non-TYP group. TYP pupils also carry out experiments with more frequency than their non-TYP counterparts, though this is not a significant difference.

Overall, pupils enjoy their Transition Year science class. This is also true for non-TYP pupils in their science classes. Due to the non-parametric nature of this data the median was used as the measure of centrality, and Mann Whitney tests were conducted in order to compare the differences between the groups. When compared with non-TYP pupils' enjoyment of their Junior Certificate science class there were no significant differences ($p = 0.963$), and a reported median value of 2.00 for both groups. These results were also true for both male and female pupils, with both equally enjoying their Transition Year science class (*Mdn* = 2.00, $p = 0.716$). This indicates that the majority of pupils enjoy their science class, regardless of the year they are in.

The majority of pupils plan to take biology in the senior cycle. A slightly higher proportion of pupils (71.6%) indicated that they planned to take this subject in response to this question, than in the previous free response question (66.1%). It is worth noting that biology is the only science subject to be offered to pupils in every school surveyed. Results between the TYP pupils and the non-TYP pupils and gender were once again compared in Chi square tests. Similar to the previous results discussed, biology was the only science subject that a significantly higher proportion of TYP pupils planned to take in the senior cycle (71.6%). Only 55.3% of non-TYP pupils planned to take this subject, and this difference was considered to be statistically significant ($p = 0.023$). Physics shows similar trends to the previous results: more TYP pupils (18.0%) plan to study the subject than non-TYP pupils (14.6%), but this difference is not statistically significant. A significantly ($p = 0.001$) higher proportion of non-TYP pupils (29.3%) planned to take chemistry, and only 16.2% of TYP pupils indicated that they planned to take the subject. A greater proportion of non-TYP pupils (35.0%) planned to take agricultural science than their TYP counter parts (11.5%), but this is not significant. Biology has a significantly ($p = 0.001$) higher proportion of female pupils planning to take the subject; this is also true for chemistry, but is not significant. The proportion of male pupils (29.8%) planning to study physics for the senior cycle is significantly ($p = 0.003$) higher than of female pupils (13.2%). Agricultural science also experiences this trend, but not significantly so. The pupils who are planning to take one or more of the various science subjects cited various reasons for their decision, such as planning for future career and potential to achieve good grades.

Over all Transition Year does not appear to overwhelmingly encourage or discourage pupils to take a science subject in the senior cycle, with only 49.8% of pupils stating that the year has encouraged them to take up a science subject in the senior cycle. When Chi square tests for gender were performed, it was found that female pupils are significantly ($p = 0.014$) more encouraged (57.8%) by the Transition Year to take up a science subject in the senior cycle than male pupils (42.6%).

DISCUSSION AND CONCLUSION

A wide variety of curricula and teaching and learning activities are present in Transition Year science classrooms around Ireland. The research questions, which guided this aspect of the overall study, are discussed here in relation to the findings.

- *What are pupils' experiences of science within the Transition Year?*

Pupils agree that Transition Year science classes are overall an enjoyable positive experience. Their science activities vary in nature from those carried out at Junior Certificate level.
The experiences of the TYP pupils differ greatly from those of the non-TYP pupils, with respect to how science is treated: TYP pupils experience more practical classes per week than their non-TYP counterparts. A contributing factor in this may be the tight curriculum constraints experienced in the study of Junior Certificate science. Not unexpectedly, there is also a clear disparity between the types of activities carried out by pupils in the two types of science classrooms.TYP have more positive experiences in their science classrooms: the activities that are carried out more frequently than their non-TYP counterparts are conducive to discovery learning (Bennett 2003, p. 75), active learning (Kyriacou 1998, p. 39), problem-based learning (Kelly 2000, Bennett 2005) and context based learning (Campbell and Lubben 2000, p. 240, Schwartz 2006), all of which has implications for improving pupils' understanding of Science (Adey *et al.* 1989, Johnstone 2000, Monk and Osbourne 2000, p. 161, Reid 2008).

- *What impact, if any does taking Transition Year sciences have on pupils' decision to take a science subject at senior cycle?*

While a higher proportion of TYP pupils than the national average planned to take up a science subject at senior cycle, the year did not encourage them to make this choice. Results indicated that female pupils were significantly ($p = 0.014$) more encouraged, by the Transition Year, to take up a senior cycle science subject. Those pupils who were encouraged by the Transition Year to take a senior cycle science subject had a higher planned uptake of physics, chemistry and biology than those who had not been encouraged to take a subject by the Transition Year. There was a significant association between whether or not the Transition Year had encouraged pupils to take a science subject in senior cycle and them deciding to take one. A significant positive association was found between pupils who enjoyed their Transition Year science class and those who were encouraged to take a Science subject by the year. Therefore, perhaps when the Transition Year science class is taught in an enjoyable fashion it does encourage uptake of science subjects for Leaving Certificate. The findings of this study echoes other studies (Milner *et al.* 1987, Smyth and Hannan 2002, Cleaves 2005, Lyons 2006, Smyth and Hannan 2006, Reardon *et al.* 2010), indicating that pupils are driven by the examination culture, and choose subjects that they feel that they will do well in and will aid them in their future. That is not to say that interest and enjoyment does not play a part in the pupils' decisions, but it is not the principal factor.
This study indicates that the Transition Year is a worthwhile and positive endeavour, which is failing to achieve its full potential in terms of pupils' experiences of science in the year.

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DEVELOPMENT OF A NEW INTERDISCIPLINARY ADVANCED SCIENCE COURSE: NATURE, LIFE & TECHNOLOGY

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Abstract: In order to motivate senior secondary students and teachers to get acquainted with new developments in science and technology a new course Nature Life & Technology (NLT) was developed between 2006 and 2011. This elective course deals with interdisciplinary issues covering a broad field of science and technology. In this paper the development process of this course is evaluated. Factors which contributed to its success were: cooperation between school teachers and science experts in developing the modular learning materials, strict quality control of these materials, agreements with school administrators about teaching conditions and a national network of regional support centres.

Keywords: curriculum development, interdisciplinary, upper secondary, science teaching, team teaching

BACKGROUND, FRAMEWORK AND PURPOSE

Across the world science curricula are in the process of revision or have recently been renewed (e.g. Atkin & Black, 2007; Millar, 2006; Ogborn, 2005; Parchmann et al., 2006; Wei, 2009). Many new initiatives in science education focus on pupils in the ages of compulsory education, primary and junior secondary, however students make decisions about their future influenced by their experiences in senior secondary school. Requirements of secondary education are often such that teachers in senior science courses have little time to deal with modern topics. In addition, modern science topics are often interdisciplinary while senior courses in science are usually monodisciplinary and teachers usually lack expertise and confidence to properly teach these topics. So in order to promote teaching interdisciplinary topics which offer students and teachers new insights into current developments in science and technology, a new elective course "Nature Life and Technology" (NLT) was created. NLT is to be taught to senior secondary students in science streams, in addition to the regular courses in physics, mathematics, chemistry and biology. Depending on the type of school students should spend 320 or 440 hours to study this course (including school and home work). Schools are free to offer the course which is assessed by a school based examination.

RATIONALE

Such advanced interdisciplinary curriculum initiatives at the senior secondary level are not common across the world and require large efforts in the fields of development of study programme, course materials, teacher training, school organization, cooperation with the world of science and technology, quality assessment and communication with parents and students. Specific challenges for the development of NLT were:

1. in the Netherlands no experience was available with this kind of courses at senior secondary level: no teaching and assessment materials, no teacher training and no experience with interdisciplinary team teaching at this level;
2. in order to make a successful start with the course in Dutch secondary education the start of the course should be in line with a structural revision of senior secondary education, i.e. September 2007, while the decision to create the course was made mid-2005. This created high pressure on the development of the course.

In this paper we will evaluate these efforts over the last five years guided by the central question: What measures were successfully taken during the curriculum development and implementation process to enhance the advanced and interdisciplinary character of NLT?

METHOD

A Steering Committee NLT was created early 2006 to take care of development, introduction, monitoring and evaluation of the first five years of NLT. The approach was to define the aims and create an outline for the new course, to develop a study programme as well as course materials (consisting of modules) and to stimulate and support schools to implement the new course (Krüger and Michels, 2007). In the period 2007 – 2010 the development and implementation of NLT was monitored by several studies, both quantitative and qualitative ones (e.g. Kuiper et al., 2010).

RESULTS

The goal of NLT is to make the natural sciences and technology more attractive and to create coherence in the different subjects of the sciences. In more detail the following aims were defined (Steering Committee NLT, 2008):

- to offer both a broader and more in-depth study programme for science and mathematics;
- to enable students to get familiar with a wide range of follow-up studies and professions;
- to let students experience the importance of interdisciplinary coherence in the development of science and technology;
- to create a closer connection between science education and new developments in society, science and technology, in interaction with higher education, research institutes and the business community;
- to offer more choices to teachers and students in the sciences at school;
- to make a contribution to permanent innovation of science education.

In order to cope with the limited amount of time a parallel course of development took place, i.e. the course outline and study programme were written in the same period in which the development of course materials started. The study programme was formulated in cooperation with teachers and students from tertiary education. The formulations were chosen very broadly so that in principle any topic relevant to a science study or profession should fit in and could therefore be developed into a module.

In order to involve teachers and schools and to ensure quality of content and didactical approach, for each module a writing team was formed which consisted of some science and mathematics teachers and an expert from higher education. In order to ensure quality of the teaching material, criteria were formulated and made known before development started. Each writing team followed a strict cyclic process of development, piloting and evaluation and revision (Eijkelhof & Kruger, 2009). Only modules which met the criteria were certified by the Steering Committee for use in NLT lessons.

Considering the lack of experience with interdisciplinary courses in Dutch education, the Steering Committee NLT formulated some requirements for those schools which wanted to implement NLT. Examples of requirements are: NLT is taught by a team of at least three teachers qualified for upper secondary with different specialism (mathematics, physics, chemistry, biology, earth science); school administrations provide means (time and finance) to these teams for professional development and preparation; schools make use of certified modules and contribute to evaluation activities. Furthermore it is encouraged that school administrations offer sufficient practical facilities; such as lab and computers and a suitable timetable to teach NLT and that students get opportunity to learn from external sources, i.e. universities, polytechnics or industry.

NLT aims to promote insight into current developments in science and technology and to assist students in a realistic orientation on a career in those fields. In order to fulfil these aims it is important to have structures in which long term and meaningful contacts exist between secondary and higher education. In 2008 the project team NLT therefore started stimulation and coordination of a national network of Regional Support Centres NLT. A Regional Support Centre consists of at least one university, one polytechnic and a number of secondary schools in the region. They form a network to support and improve teaching and learning of NLT. The universities and polytechnics also take care of maintenance and updating of the certified modules.

Table 1
Examples of Topics of Certified Modules

Pre-college level	**Pre-university level**
Air pollution and aerosols	Artificial kidneys and membranes
Alcohol and traffic	Bioinformatics
Biotechnology	Biosensors
Epidemics in agriculture	Brains and learning
Forensic science	Chemical cooking
Glass horticulture and energy	City climates
Glue and adhering	Climate change in the north pole area
Heart diseases	Cystic Fibrosis
Making and tasting bread	Food or fuel: 2nd generation biofuel
Medical imaging	Heart diseases
Optimizing achievement in sports	Holograms
Surviving in the international space station	Hydrogen cars
Sustainability in schools	Medicins: from molecules to humans
Sustainable soil management	Moving continents
User friendly technology in health care	Nanoscience and technology
Using GIS for safety	Nuclear fusion
Water purification	Room for rivers: redesigning river forelands to avoid flooding
Zero-energy house	Stellar course of life

During 2007 – 2011, 66 modules were developed and certified by the Steering Committee NLT. Teachers from 96 different schools were involved in developing modules and teachers from 54 other schools tested the materials, scientific experts came from 10 different universities, 12 colleges and 25 other institutes, such as research institutes and industry. The total number of developers was 436. Table 1 shows some examples of topics covered by these modules.

From the analysis of registration data it is found that in almost all NLT teams a biology (97%) and a physics (96%) teacher are involved, followed by chemistry (89%) and mathematics (75%). In 45% of the NLT teams a geography teacher is present.

In September 2010 the number of registered NLT schools was 230, i.e. 44% of all senior secondary schools in the Netherlands. Schools mainly use the certified modules.

CONCLUSIONS AND IMPLICATIONS

As might be expected from such an innovative course as NLT several problems were faced during the development and implementation. There was a lack of suitable study and teaching materials, in combination with the urge to meet high standards in content and pedagogy in order to make such a new course feasible and attractive for students and teachers and approved by science experts (Eijkelhof & Kapteijn, 2000).Teachers in secondary schools lack sufficient knowledge about current developments in science and technology and tend to focus strongly on the teaching culture in their own schools; scientists appear to overestimate the knowledge of high school students and to miss the ability to design suitable student activities. The formation of writing teams existing of teachers from at least two different schools and science experts, combined with the use of a strict quality assurance procedure, including piloting in independent schools and collecting expert reviews proved a successful strategy.

For many schools the requirement to form teaching teams was quite new; it resulted in new forms of cooperation between teachers and in novel ways of time tabling.

Scientists usually are highly involved in their own research and teaching in higher education. Nevertheless almost all universities and many polytechnic colleges cooperated in a variety of ways in designing materials and supporting schools during teaching. Possibly because it was in their interest to make their field of expertise accessible to prospective students or simply because they enjoyed contributing to development of teaching materials on topics in which they were highly and enthusiastically involved as professionals.

In our view a course such as NLT is relevant to educational systems in other countries for various reasons:

- Lack of enthusiasm for science and technology careers is an issue in many countries and might be reduced by (re)connecting school science to developments in research institutes and industry.
- Interdisciplinary topics often have global implications which could well be addressed in the course materials.
- This type of course offers opportunities for teachers for life long learning in their own and neighbouring field of expertise.

Therefore we would be highly interested in developing a network of curriculum projects with similar aims. It is time to share materials and good practices in this field.

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A CASE STUDY OF AN ESD PROGRAMME FOR COLLEGE STUDENTS IN JAPAN: PILOT PRACTICE AND EVALUATION

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Abstract: Since the United Nations Decade of ESD commencement, science education for ESD has manifested a new energy. While the Cabinet Office of Japan notes that one of the objectives of ESD is to raise public awareness of the need for SD, many students are not conscious of this necessary growth path. Hence, this study seeks to develop a pilot programme with the educational objective of increasing SD awareness. As a result, it appears that students found concrete issues and subjects of SD in everyday life by the end of the programme, while their knowledge of this subject was poor at the beginning. Moreover, the students came to understand SD-oriented issues as familiar occurrences in their daily lives. To conclude, it is suggested that a positive outcome was obtained by the pilot programme in promoting student awareness of SD. In addition, it is pointed out that activities of SD and ESD in Japan have mainly progressed in environmental aspects for students.

Keywords: Education for Sustainable Development (ESD), Higher Education, Public Awareness, Practice and Evaluation

INTRODUCTION

The United Nations Decade of Education for Sustainable Development (ESD) began in 2005 (UNESCO, 2005). Since its commencement, science education for ESD has manifested a new energy in Science Education (Fensham, 2008). For instance, in Japan, ESD has become an important theme that has attracted the attention of the Japan Society for Science Education (see, for example, Abe, 2007; Nogami, 2010). Ogra (2008) suggested that practical programme development is expected in consideration of the local context in ESD. The importance to consider the local context are also described in assessing scientific literacy as PISA 2006 (OECD, 2007) . Furthermore, the educational projects of universities and colleges are flourishing (see, for example, Dawe et al., 2005;Itoh et al., 2008). ESD focuses on a range of subjects such as the environment, human rights, and health and safety (UNESCO 2005). Therefore, its educational objectives and content may differ by country and area.

What is required for ESD in Japan? The Cabinet Office of Japan (2008) notes that one of the objectives of ESD is to raise public awareness of the need for sustainable development (SD). However, many students are not conscious of this necessary growth path, since both SD and ESD are new social concepts.

RATIONALE

The Cabinet Secretariat of Japan indicates, ‘As an outcome of ESD, it is expected that people can change unconscious decision-making into concrete social action. It is also a key to reform education and the value norm (2008)’, and ‘ESD is the education for every people to recognize that they live in the global world, and have the relationship with the future generations and environment (2009)’. UNESCO (2009) calls attention to the necessity to 'raise public awareness of the concept of sustainable development'. Burns et al. (2003) define public awareness of science (PAS) as 'a set of positive attitudes towards science (and technology) that are evidenced by a series of skills and behavioural intentions'. In sum, awareness of SD may be the key issue for an ESD programme. However, few studies clarify student awareness of SD. What is SD for Japanese students? Do they know about SD, and can they identify it and the issues related to it in their surroundings? In this regard, it is important to raise the SD awareness of students who will lead society in the future. Incidentally, it is indispensable to use an effective information and communication technology (ICT) tool when developing a scientific educational programme (Fensham, 2008). Hence this study seeks to develop a pilot programme with the educational objective of increasing SD awareness and to employ an effective ICT tool in this process.

PURPOSE AND PROCEDURE OF THE STUDY

Purpose

In this study, the design and practice of a pilot SD awareness programme for college students is first outlined. Then, the results of the pre-tests and post-tests of the students' SD awareness are revealed in terms of the evaluation of the pilot programme. In addition, characteristics of concrete SD images among the present students are considered based on the programme contents.

Design of the Programme

The programme was performed 15 times in 90-minute weekly sessions. The contents of the programme included (1) introduction and lectures for five weeks, (2) class-work and fieldwork by students for five weeks, and (3) student group discussions and a summary of the programme for five weeks.

The 'ClipGallery' was developed by one of the authors as the effective ICT tool of for the fieldwork in the activity of (2) (Takenaka et al., 2005). The system configuration of the ClipGallery is shown in Figure 1. Students took photographs of SD-oriented issues on their mobile phones and sent them to the ClipGallery. They discussed 'Of what', 'Where', and 'Why' they took the photographs within their groups.

Period of Investigation and Target Students

Period: 20 April 2010–27 July 2010 (pre-test: 27 April; post-test: 27 July)

Target Students: 34 students in Kobe College, Japan

Contents of Investigation for Students' Awareness of SD

(1) Word association (pre-test and post-test)

Key word/phrase: 'Sustainable development is'
Time to answer: 5 minutes

(2) Multiple questionnaires in four scales (pre-test and post-test)

'4: strongly agree'; '3: slightly agree'; '2: slightly disagree'; and '1: strongly disagree'

(3) Photographs in the ClipGallery by students

Students write (a) the title-'Of what', (b) the place-'Where' and (c) the reason 'Why' to the photographs that they took in the web list of the ClipGallery.

RESULTS & IMPLICATIONS

The results of ‘Word association’ and ‘Multiple questionnaires’ are respectively shown in Tables 1 and 2. Using ‘Word association’ (Table 1), it appears that students found concrete issues and subjects of SD in everyday life by the end of the programme, while their knowledge of this subject was poor at the beginning. For example, the number of association words is significantly increased in the post-test. The same trend is clearly shown in the average, the minimum and the maximum number of words per person. From Table 2, we find that the scores of the post-test are higher for almost all questions than those of the pre-test. These facts reveal that students gained a concrete sense of SD after their fieldwork using the ClipGallery, and they came to understand SD-oriented issues as familiar occurrences in their daily lives.

The total number of photographs registered in the ClipGallery is 249. Examples are shown in Figure 2. A student took a photograph of ‘Recycle boxes’ as SD issue. She described a reason as ‘we can prevent to use new resource by recycling so that good environment will be kept. (Figure 3(1))’. Another students showed an ‘eco bag’ as SD oriented issue and explained ‘Eco bags are reusable. They reduce rubbish of plastic bags. This also reduce damage for environment.(Figure 3(2))’

Table 3 shows the association words and reasons expressed by ten or more students. Majority of the students, over 70%, are reminded of the term of ‘Recycle’. They also noted ‘Recycled paper’. This fact shows that the most represented words and images of SD among students is ‘Recycle’. Moreover, there are the terms of ‘My chopsticks’, an ‘Eco bag’ and ‘My tumbler’. These words mean that students are conscious of bringing their own chopsticks, bags and tumblers, instead of using the disposable items offered by the shops. Therefore, these terms may indicate a common consciousness in students that they need to reduce disposable item use. The idea of reducing disposable item use is reflected also in the word of ‘Ziploc®[1]’. In addition, students may understand the phenomenon relevant to power generation and energy savings as SD, because they find solar-power generation, wind-power generation, a solar panel, energy saving and an eco car as SD oriented terms. Bicycles and ‘EcoNavi[2]’ are also raised with the reason of energy saving. The word of ‘Organic’ is represented as health issue as well as environmental friendly.

The above issue points the notes that students tend to consider of taking environment-friendly action, such as to avoid disposable item use, recycle and energy saving, as SD. Some students chose photographs and described words of goods and product names. This issue means that the advertisement and promotion by private companies may be a factor to form students’ SD images. From this study, it may be suggested that activities of SD and ESD in Japan have mainly progressed in environmental aspects for students.

SD is a modern slogan in the promotion of science education. I would like to investigate students image of SD and to develop effective educational programme for ESD towards students.

ACKNOWLEDGEMENT

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NOTES

1. ‘Ziploc’ is a registered trademark of Asahi Kasei Home Products Corporation. (Products. http://www.asahi-kasei.co.jp/ saran/products/ziploc/, access date 19th September 2011)

2. ‘EcoNavi’ is a power saving technology with which the products of Panasonic Corporation are equipped. (What is EcoNavi ıttp:// panasonic.jp/econavi/about/index.html. hccess date access date 19th September 2011)

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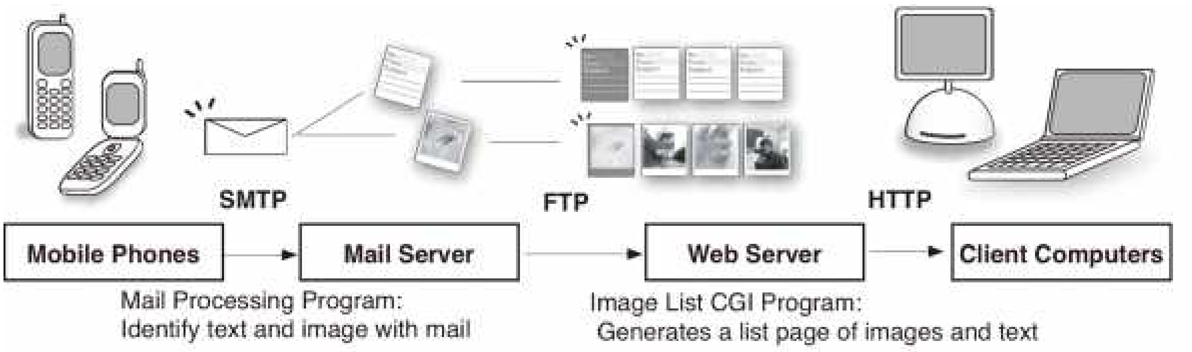

Fig 1 The System Configuration of the "ClipGallery"

Table 1 Results of Word Association (N=34)

	Pre-test → Post-test
The number of total words**	311→ 1097
The average number of words/person**	8.9 → 31.3
The minimum number of words/person**	3 → 14
The maximum number of words/person**	18 → 50

Table 2 Multiple-Choice Questions and Results (N=34)

Questions	Average Score Pre-test→Post-test
1. I know the word of "Sustainable Development"*.	3.0→3.7
2. It is important to carry out "Sustainable Development".	3.7→3.9
3."Sustainable Development" is the issue that the National government should carry out.	3.5→3.6
4."Sustainable Development" is the issue that industrial companies should carry out.	3.5→3.5
5."Sustainable Development" is the issue that scientists and professionals should carry out.	3.1→3.2
6."Sustainable Development" is the issue that citizens should carry out.	3.3→3.7
7."Sustainable Development" is the issue that I should carry out*.	3.2→3.7
8.Undertakings for "Sustainable Development" have already started**.	2.8→3.5
9.It is easy to find concrete undertakings for "Sustainable Development" in our daily life**.	2.4→3.7
10. I know concrete undertakings for "Sustainable Development"**.	1.9→4.0

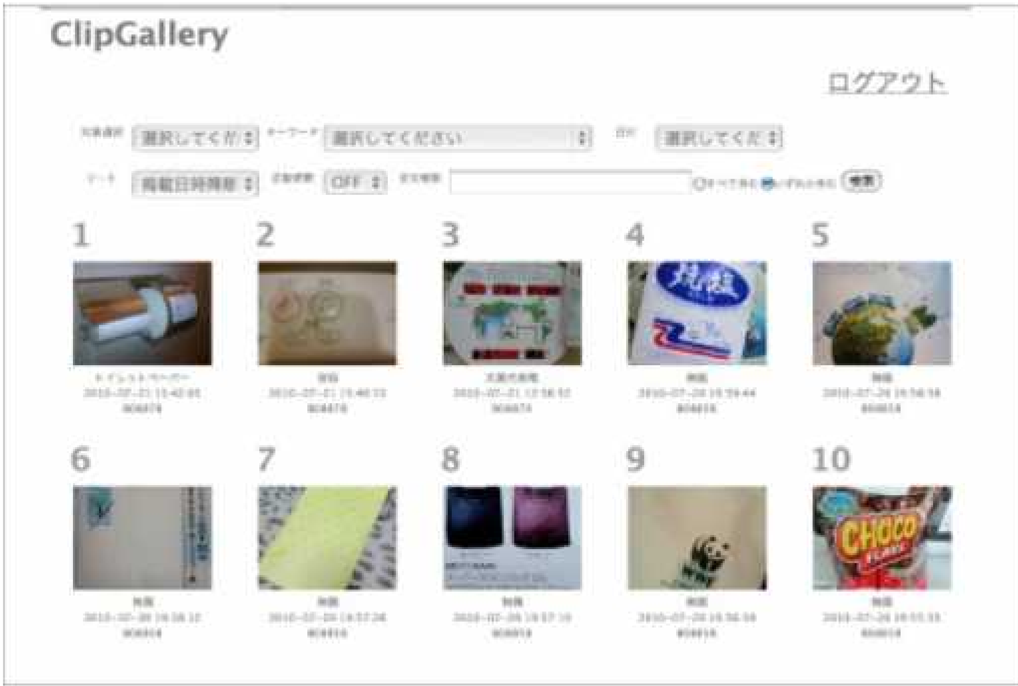

Fig 2 An Example of Photographs in the "ClipGallery"

Place: Supermarket
Reason why this SD
We can prevent to use new resource by recycling so that good environment will be kept.

Place: My room
Reason why this SD
Eco bags are reusable. They reduce rubbish of plastic bags. This also reduce damage for environment.

Fig 3 Example Photographs and their Titles and Reasons

Table 3. List of the association words and reasons expressed by ten or more students

Assiciation Word	Number of Students	Example Reasons for SD (Because it leads to)
Recycle	27	Environmental friendly action/Recycle for natural environment/ Useage of recycled items
My Chopsticks	25	Reducing rubbish/ Reducing timber comsumption/ Repeatedly usage/ Sustainable development for woods/ Environmental conservation
Eco Bag	23	Less usage of plastic bags/ Reducing usage of natural sourses / Reducing rubbish/ Environmental friendly action/ Protection for natural enviroonment and sources
Solar Powere Generation	23	Saving energy usage/ Reducing carbon dioxide emmision/ Usage of natural energy/ Environmental friendly action
Bicycle	22	Avoiding to waste of energy/ Reducing carbon dioxide emmission/ Sustainable use by changing parts
My Tumbler	20	Reducing usage of natural sourses/ Reducing rubbish
Wind Powere Generation	19	Producing energy by wind/ Usage of natural energy
Solar Panel	16	Reducing carbon dioxide emmission
Ziploc®	16	Repeatedly usage/ Recycle
Sweden	15	Learning of sustainable development society/ A develped country of environmental policy
Energy Saving	14	Reducing energy comsumption/ Reducing carbon dioxide emmision/
Eco Car	14	Fuel efficiency
Organic	14	Environmental friendly action/ Solving a problem of environmental distuption and health damage
Recycled Paper	13	Environmental friendly action/ Protect woods
EcoNavi	11	Change energy consumption in a day by time (less energy consumption in night time)

CURRICULUM STANDARDS FOR TEACHING PHYSICS IN BRAZIL

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Abstract: This work, as part of a PhD thesis, aims to investigate and monitor the whole process of development and implementation of curriculum standards for physics which has been made in the state of Rio Grande do Sul, Brazil. We have analyzed the development process (in which the authors of the present work have participated), the continuous teachers training process, and their implementation in the classroom, by investigating how teachers react to these changes and if something really changes in their physics teaching activities. All the research is enlightened by the Wertsch sociocultural perspective (Wertsch, 1993), which integrates Vygotsky and Bakhtin theories. We also take into account that the actions of these teachers are guided by their professional knowledge (Porlán et al., 1997 and 1998). We had used a qualitative approach, with participant observation, using as sources official documents, video recordings of training courses for teachers and classroom interventions, as well as semi-structured interviews. Preliminary results indicate that the problems in the organization of the development process have given rise to a material in which, among other inconsistencies, the interdisciplinarity have been barely addressed. Also, there was little autonomy given for teachers to implement the necessary changes because the training process was focused mainly on content topics, devoting much little space for discussions about important pedagogical issues which could guide the teachers to promote better classroom implementation of these curricular standards.

Keywords: physics curriculum, continuing education of teachers, educational policies, reports of experiences.

1. STRUCTURE AND PUBLIC POLICIES FOR EDUCATION IN BRAZIL

Brazil is going through a slow process of curriculum change which truly began in 1996 when was approved a law called “Guidelines and Bases for Education” (LDB), which establishes compulsory a primary education of eight years (increased to nine years in 2001) and secondary school of three years (see table 1). These guidelines also provide that the federal government, in collaboration with the several state and municipal governments, should establish ways to guide these curricula.

According to this law, the Curriculum Guidelines were approved in 1998 and establish that the high school level, the only level in which physics is taught, will be organized in three knowledge areas: 1 - Languages, Codes and its Technologies, 2 - Natural Sciences, Mathematics and its Technologies and 3 - Humanities and its Technologies. Moreover, these guidelines also stated that the main focus of the teaching process may be directed to the development of abilities and competences related to these areas, and not only to its content topics. Also, the importance of interdisciplinarity and context based learning are emphasized.

Age	Duration	Appropriate Designation	National Common Base
6 -14	9 years	Ensino Fundamental (primary education)	• Portuguese • Native language (indigenous and migrants) • Mathematics • Science • Geography • History • Foreign language • Art Education • Physical Education • Religious Education
15-17	3 years	Ensino Médio (secondary education)	• Languages, Codes and its Technologies • Natural Sciences, Mathematics and its Technologies • Humanities and its Technologies

Table 1 - Organization of primary and secondary education free and compulsory in Brazil

In 2000 and 2002 the Federal Government published the National Curriculum Parameters (PCNs) and, subsequently, the Curriculum Guidelines for High School Level in 2006. All these guidelines possess non-compulsory character. However, despite they establish and reinforce the teaching focused in abilities and competences (for political and structural reasons), they have not improved effectively the education in Brazil. One consequence in physics teaching is that the physics classrooms in high school level remain centered basically in simple formula application and resolution of exercises, as shown, for example, in the work of Ricardo (2005) and Ricardo & Zylbersztajn (2002).

<table>
<tr><th>Public Policy</th><th>Implications for Secondary School</th><th>Nature</th></tr>
<tr><td>LDB (1996)
Law of Directives and Bases of National Education</td><td>• Establishes the development of national and regional curriculum proposals
• Promotes autonomy for schools and teachers</td><td rowspan="2">Mandatory</td></tr>
<tr><td>DCNEM (1998)
National Curriculum Guidelines for secondary school</td><td>• Development of abilities and competencies in student, using interdisciplinarity and contextualization</td></tr>
<tr><td>PCN (2000), PCN+(2002) e Curriculum Guidelines for Secondary Education (2006)</td><td>• Natural Sciences: Biology, Chemistry and Physics
• Establishes content blocks and procedures</td><td rowspan="3">Optional</td></tr>
<tr><td>State Curriculum Proposals: Minas Gerais, São Paulo, Paraná, Rio Grande do Sul (2009), Santa Catarina e Goiás</td><td>regionalization</td></tr>
<tr><td>Municipal Curriculum proposals</td><td>In early implementation</td></tr>
</table>

Table 2 - Main resolutions in public policy for education in Brazil

In the State of Rio Grande do Sul (see figure 1), these national guidelines have not experienced much penetration and only in 2008 the local authorities developed the curriculum standards for this state, as an answer to the quite unsatisfactory performance of students in the state and national evaluation exams. This document was supported by the national guidelines

(PCNs and Curriculum Guidelines for High School Level) and was developed by a team of consultants, at least two per knowledge area.

Figure 1 - State of Rio Grande Sul highlighted in red on the Brazil's map.

This work reports this whole curriculum change process in the state of Rio Grande do Sul and investigates how teachers have reacted to these changes and if it really improves the physics classrooms, as expected.

2. PROPOSED CURRICULUM FOR PHYSICS EDUCATION OF RIO GRANDE DO SUL

Figure 2 - Curriculum guidelines Sciences, student and teacher's books.

The government actions at Rio Grande do Sul, for both primary and high school level, is directed to improve education by focusing the student learning on the development of abilities and competences, highlighting what we call basic transversal competences (reading, writing and solving problems) and, additionally, giving special attention to context based learning and interdisciplinarity. From this perspective, the main goal of the education process is shifted from the content topics to be learned to the development of skills (abilities and competences) articulated to these topics, since they need to be contextualized, articulated and applied to other areas of knowledge than physics (see figure 3).

Regarding the content of physics, the proposed curriculum does not bring new features compared to other official documents, but seeks to contextualize and illustrate his proposals, discussing in depth about the purpose of teaching physics and how to do it, pointing out appropriate strategies for this purpose. We chose to suggest a single sequence proposed in this paper, derived from official texts, which begins in the first year of high school, with the topic "Universe, Earth and Life."

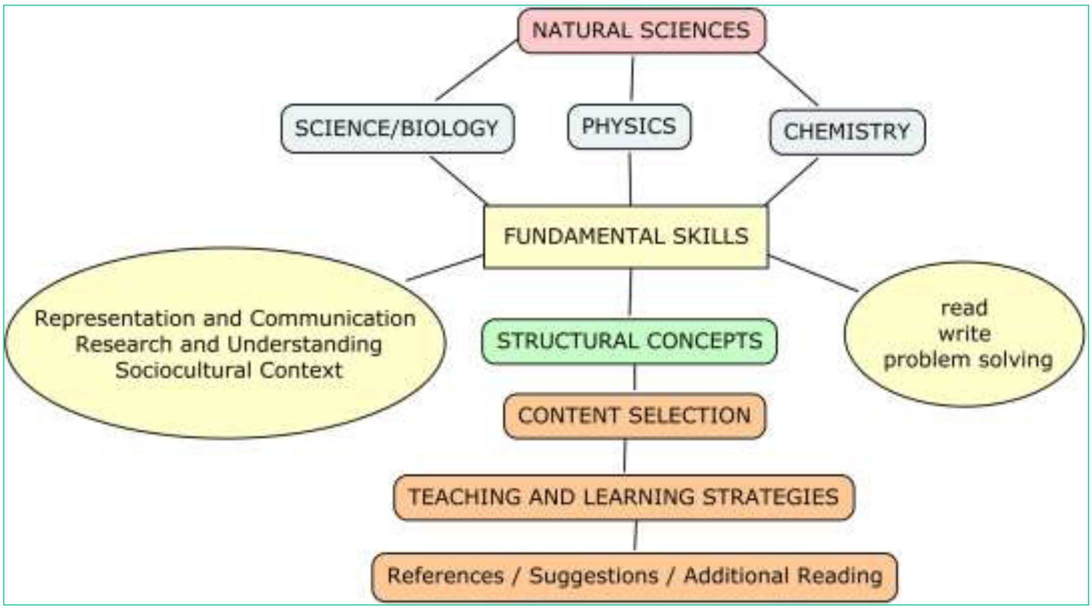

Figure 3 - Structure of the curriculum guidelines of Rio Grande do Sul.

This sequence was chosen because its potential to bring enthusiasm to students in their first contact with Physics. It has been thought to be developed under the structurating theme called "Universe, Earth and Life," which covers issues relating to the origin of the universe and our planet and all the Physics contents relevant to school. To assist the teacher in this process, since the textbooks do not deal with this approach, we have written a guide to the teachers showing how to start and advance the study and, additionally, providing a text with diversified activities on this topic, suggesting additional references.

Physics in secondary school	1º year	2º year	3º year
1st half	Universe, Earth and life	Sound, image and information	Electrical equipment and telecommunications
2nd half	Movements: changes and conservations	Heat, environment and energy uses	Matter and radiation

Table 3 - Suggested content distribution on the curriculum guidelines of Rio Grande do Sul

This topic can also help the approach of natural sciences in high school to establish in an interdisciplinary way, since all other topics in this area have close relationships with it. We believe that this could be a good alternative to start working interdisciplinarity with students and.

3. RATIONALE

The impact of these new educational policies is analyzed on a sociocultural framework (Wertsch, 1993), taking into account that the actions of these teachers are guided by their professional knowledge (Porlán et al., 1997, 1998). We adopt the curriculum perspective of Silva (2010), a renowned Brazilian specialist on curriculum theory.

These frameworks provide the elements needed to support the understanding of the psychological processes involved, the discourse and actions of some physics instructors throughout the process focused by this study.

4. METHODS

The research approach has involved the direct and prolonged contact between the researcher, the environment and the situation being investigated, usually through intensive field work. The qualitative research is known suitable in this case, because it aims to “capture the multidimensional nature of the phenomena in their natural expressions and capture the different meanings of lived experiences” (Rosa & Arnoldi, 2006, p.66).

Several sources had been used:

- Analysis of the development process of physics curricular standards and its possible implementations in the classroom;
- Video recording and collection of written material in the teachers training;
- Semi-structured interviews with teachers and the *multipliers* (professionals responsible for conducting the teachers training process) and governmental authorities.

Observations were conducted and the method chosen was the *participant observation* (Rosa & Arnoldi, 2006).

5. PRELIMINARY RESULTS, CONCLUSIONS AND IMPLICATIONS

Like any public policy in Brazil, the curriculum standards for Physics of the State of Rio Grande do Sul was slowly developed (2 years). Although the consultants' work has been done with much liberty, the weak interaction between the members of the consultant team has to be mentioned. A major result of this flaw is the lack of better integration between the texts of the standards of the *Natural Science* knowledge area (comprising physics, chemistry and biology), which goes against the pedagogical principles of these standards which stand the interdisciplinarity as a fundamental aspect in science education.

In the particular case of physics, it had been developed in some degree of agreement with other official documents, but it attempts to contextualize and illustrate their proposals, bringing to the teacher fruitful discussions on the purpose of teaching physics, pointing out appropriate strategies to achieve this intent. It suggests that teachers should begin the physics classes in an interdisciplinary and contextualized way, adopting the topic “The origin of the universe”, articulating their proposals with the ones of chemistry and biology teachers. However, this was frustrated by the way by which the standards of other areas (biology and chemistry) had been built. They departed from different themes and this interesting topic is not covered by the textbooks commonly used in Brazil.

The state government has offered courses for the teachers, addressing fundamentals of the new curriculum standards in the State of Rio Grande do Sul. These courses were performed by trained personnel, but the poor logistic organization undoubtedly brought many difficulties to the teachers understanding of the proposal. We also observed political problems in some cities in which we have followed the courses, disrupting the work that teachers should perform.

It is worth to mention the little autonomy left to the teachers to implement the main goals of these standards in their classroom activities. We have attributed this problem in part to the problematic conception of the training courses, mostly focused in content topics without exploring the suggested methodologies of teaching and learning physics. To perform an education project based on abilities and competences, in which the context based learning and interdisciplinarity plays an important role, it would be required to give total autonomy to the teacher. Besides, the teachers' knowledge on how to deal with context based learning and interdisciplinarity in their classes, was not well addressed. An example of this little autonomy can be seen in the final projects that teachers have developed along the course, which mostly turns the classes more fun and informative, reducing the interdisciplinary character to a simple choice of a common theme between different knowledge areas, without showing the strong relationships between them and how these relationships can constitute a whole new body of knowledge.

The future of these standards is uncertain, as the state undergone a great change in its political direction in last elections. Despite this, we will continue to investigate the future implementations of these standards in physics classrooms.

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TEACHERS' VIEW ON A NEW SCIENCE SUBJECT: SCIENCE FOR THE CONTEMPORARY WORLD

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Abstract: This research analyzes the implementation of a new subject for the post-compulsory secondary school called "Science for the Contemporary World" (SCW). The main goal of this research is to identify the differences between the implemented curriculum as reported by teachers (IC), and the Potential Curriculum (PC) for this subject according to the official curriculum, science education literature and other theoretical sources. SCW demands from teachers a challenging new conceptualization of science and science teaching, within the competence-based and science for public understanding perspective

This paper presents the results obtained from a series of interviews to both innovative and standard teachers. Data analysis shows that there are different ways of interpreting the new subject among them, in particular regarding what, why and how to teach, signalling four different models or profiles for the subject.

Keywords: Science for the contemporary world, Science for Public Understanding, Curriculum, Competence-based Framework, teachers' perceptions

BACKGROUND, FRAMEWORK, AND PURPOSE

During 2006, the education law was modified in Spain with the approval of the Spanish Organic Law (LOE) which generated a new official curriculum that included a new subject for the post-compulsory secondary school: *science for the contemporary world* (SCW).

This subject has no precedent in post-compulsory education –post-16 years old-. Despite in this period the students have to choose between different areas (humanistic or scientific) with different subjects, SCW is compulsory to all of them. In this sense, it is a scientific subject for all at the post-compulsory level. Other characteristics of SCW are that it has 2 hs. class per week is a minor subject in terms of length and role in the external evaluation (it is not included in the external university entrance examination) and it can be taught by teachers with very different profiles (not only science teachers but also humanistic teachers such as philosophers) . Finally, one of the main characteristics of SCW is its open curriculum, which means that there are some general guidelines published at official level, but the subject is presented as not rigid and organized around five main themes to be studied at wish: Our place in the Universe, Health, Sustainability, New materials and Global information.

The main goal for the introduction of this new subject is reducing the deficit of scientific knowledge of citizens within a *science for all* and *STS* perspective. To do so, SCW follows the curricular trend of many countries inspired in the work of Fensham (2002), Hurd (1998), Jenkins (1999), Millers (2004) and Osborne (2002), among others.

This research aims to identify the vision and patterns of implementation of the subject according to teachers' perceptions of SCW and reports of their practice, to make explicit what we call the Implemented Curriculum (IC). The purpose is to compare the IC with the Potential

Curriculum (PC) of the subject, defined by the official curriculum and current research in science education.

Hence, the research questions we expect to answer are: What are the similarities and differences between the Potential Curriculum (PC) and the Implemented Curriculum (IC) of SCW, according to the teachers? What is the teachers' perception about SCW? Can the differences between the PC and the IC be related to teachers' science education expertise?

RATIONALE

We have characterized the PC based on both the official curriculum and the extensive literature on proposals for scientific education with a socio-cultural emphasis that inspire the theoretical rationale of this subject. Regarding the literature review, frameworks such as STS, Science for all, and projects such as Public Understanding of Science (1985) were reviewed. The characterization process let us identify three intended didactical goals for the new syllabus:

a) **Promote the development of competences to perform well in society**. This goal is not related to the concept acquisition of classical science subject-matter knowledge, but about how students learn to *mobilize* concepts, procedures and scientific attitudes, in order to solve a complex problem and make rational decisions. This research is based on the competence framework defined by the DeSeCo program (2001) and the official curriculum.

b) **Emphasize science as a product of culture.** The PC is referred to the vision of science which comes up from the intersection between science and the broader social context in which its products and processes are situated. They are typically part of public discourse, and require certain sets of skills and abilities from those engaged in reasoning and argumentation about them (Forbes & Davis, 2008). This justifies the need for a scientific literacy citizenship.

c) **Use relevant contexts to address the learning of contents**. In SCW it is expected that the selection of content is relevant to students. Also, it has to facilitate meaningful learning of scientific knowledge to be transferred to other contexts and situations. From the educational point of view, the approach would allow a balance between the teaching of science as preparation for science, and science education for citizenship (Gilbert, Bulte, & Pilot, 2011) .

In order to reach the previous goals, SCW has to be conceptualized and implemented by teachers properly. This involves that teachers' should develop a particular Didactical Content Knowledge for SCW, a concept analogous to the PCK framework that it is common in the Anglo-Saxon community. According to Henze et al (2007) characterization of PCK, this implies teachers' knowledge of 1) the instructional strategies concerning a specific topic (SCW), 2) students' understanding of this topic, 3) ways to assess students' understanding of this topic (all three relevant aspects of *how to teach*), and 4) goals and objectives for teaching the topic in the curriculum (*why to teach*). Within the perspective of didactical transposition for school science that we hold (Izquierdo & Adúriz-Bravo, 2003), it is necessary to add to Henze's definition of PCK and emphasis on a reflection and re-elaboration of the actual content or *what to teach?* In this sense, this work structures the analysis of the PC and the different patterns of the IC identified around the key dimensions: *How to teach? Why to teach?* and *What to teach?*

METHODS

For characterizing the IC an empirical study was made. During the first year the subject was implemented, five "innovative teachers" (IT) were selected and interviewed (T1, T2, T3, T4, T5). They were defined as innovative due to the fact that they held strong connections to science education research and were part of innovative teacher groups. During the second year of implementation another five interviews were done, this time to "standard teachers" (ST) who were known as not having links with research groups in science education (T6, T7, T8, T9, T10). All teachers in our sample had different scientific backgrounds and were interviewed the first year that they were in charge of the SCW subject.

The interviews were semi-structured, face-to-face and detailed with approximately 1h of duration. Teachers were asked to share their perceptions on the subject and to discuss the actual programmed and materials they were using to teach it.

From the analysis of teachers' answers we have developed 3 systemic networks for each key dimension (*what? why?* and *how to teach?*). For each network, main categories and several subcategories were identified at different levels, depending on teachers' PC understanding.

The categorization process of the interviews was carried out by analyzing the transcripts from all the interviews, the reflections teachers' send and other portfolio documents that were shared, according to the Constant Comparative Method (Huberman & Miles, 2002).

RESULTS

In this section we will show the most relevant results obtained for the three key studied dimensions: *What*? *Why*? and *How* to teach?

We start the comparison between teachers' viewpoint and the PC by analyzing their views on the first dimension, *why* to teach? (Table 1). For the sake of space, only one aspect is shown in depth. This is the category *Role of the subject in the students' curriculum,* which help us to identify how the teacher interprets the grounds on which the subject is based.

The more relevant result in this category is the difference between teachers' view on the goal of the subject. In our sample two extreme goals are identified, which are *Extending what we know about science* and *applying what we know about science.* Whereas the latter viewpoint, basically hold by innovative teachers (IT), is related to the idea of scientific competence and thus more coherent with the PC, the first standpoint (more specific of the ST group) is that of a subject complementary to the other science subjects the students have.

			Viewpoint coherent with PC	**Viewpoint dissonant with PC**
Why to teach?	Role of the subject in the students' curriculum	Extend what we know *about* science	**T1,T4, T5**,T8	
		Apply what we know about science	**T2,T3,T4,T5**	
		Extend what we know *of* science		T6,T9,T10
	Development of students'	Critical thinking about science and society	**T2,T3,T4**,T8	
		General culture: as Scientific culture	**T2**,T8,T7, **T5**,T9	
		General culture: as information		**T5**,T6,T9,T10
		More traditional science content		T6,T7,T10

Table 1- Why to teach?

In addition, the category *Development of students'*, identifies the objectives in relation to the knowledge that students must meet. The more relevant aspect in the general culture is the difference in the way in which teachers conceive this category, one of them according to the PC.

On the one hand we found general culture as scientific culture that is the students must have a certain mastery of scientific knowledge. This implies they can understand, and consequently apply, the scientific knowledge in different contexts and situations at the society. In the other hand, we have the category general culture as information, where the point of view is not consonant with the PC, teachers consider that it is only necessary that the students are within reach of the information and knowledge on the scientific leading edge.

This difference is important, because depending on how the teachers understand the concept of scientific culture, it will be reflected in their understanding and work in class.

Regarding the contents of the subject (*What* to teach?), the analysis shows that the aim of interdisciplinarity of the PC becomes a challenge to both IT and ST teachers, who both express a tendency towards teaching topics related with their scientific background. However, there are differences between these two teacher groups regarding to the selection of contents. While ST teachers refer mostly to topics within the subject textbook, IT teachers show more opened to contents related to current events. In addition IT expresses the importance of working with meta-disciplinar contents such as diversity of organisms or materials, remarking the need to work within the competence perspective of the PC.

One relevant aspect regarding what is taught is teachers' flexibility to change the sequence of contents. In general almost all teachers follow a standard curriculum model following the order proposed in the textbook or official curriculum. Also, they have shown some concern for complying with the syllabus, which is a characteristic of the traditional science subjects that have a closed syllabus which would be subject of an external examination, but shouldn't be the case in SCW where the curriculum is explicitly left open.

Regarding the dimension *How* to teach?, an interesting difference between both teacher groups is that of IT teachers facing the challenge of selecting and implementing new methods for a new subject, whereas ST teachers seem not to face this problem. In this sense, IT teachers introduce innovative classroom strategies and activities (discussions, role play, evaluation, etc.), despite stating that they have difficulties to manage them. ST teachers, on the contrary, do not state any methodological difficulties because their classes are based on traditional teaching methods and content. The most common difficulty for IT lays in the assessment of learning, in order to prove that the student can solve problems competently, i.e. how to evaluate the new activities. ST teachers consider that it is important that students learn scientific concepts, and hence, the tests are based on conceptual evaluations and show less difficulty for them.

Different ways of understanding SCW

From the analysis of the interviews and taking into account the three dimensions mentioned above, we have found different ways of understanding the subject, which we call models of the subject. These models may or may not be in complete agreement with the PC and can show coherence or incoherence between the portrayed vision of why, what and how to teach. These identified models are: *Epistemic model*, *Utilitarian model*, *Controversial model*, and *Academic inspired model*.

The *Epistemic model* is defined by a subject that let us know what science is and how it works. In this model the most important goal is to deepen the scientific knowledge of students, not only of science but about science. In this sense, the goal is on one hand to learn how scientific knowledge is generated (issues related to the nature of science), and on the other hand the Epistemic model also gives importance to the refining of conceptual models of the student.

The next example is of teacher T1, whose perceptions of SCW inspired this model.

> “[the goal of the subject is] on one hand to see **the great theories** that allow us to see the world. Some of the most important are: where do we come from? How do we work [...]? And on the other hand, **how science works**”

The *Utility model* defines a subject that help us in daily science related contexts. Is a subject in which the students apply the content learned in previous scientific and traditional subjects to everyday life situations, and so they are working on socio-scientific issues, in context and globally. Hence, the teaching and learning is devoted to the mastery of applying science to daily contexts and not the mastery of the content per se.

The next sentence of the teacher T4 showed an example of this model’s philosophy.

"We will do **things that are day-to-day,** and they are things which, even though in Greek philology graduates are perhaps of interest to you, because **maybe one day you'll have to decide** if you want assisted reproduction or not [...], and to decide that they must know something”

The *Controversial model* defines a subject that overall help us to recognize controversies and make decisions when ethical issues are involved. This model pays more attention to the controversial nature of most scientific issues of social importance today, and the need to be critical on them. The next example of teacher T3 describes this model:

> "[the objective of the subject is to] train future citizens to have a **critical view of science or current affairs** [...], learn to be critical, to have an opinion and know that all are valid, that all can be defended”

The *Academic model* defines a view of the subject as one devoted to learn more science, both reinforcing previous knowledge and learning about the new scientific advances. This model emphasizes the needed to learn more, updated scientific knowledge without the critical thinking standpoint. The next example shows a sentence of teacher T10, whose view inspired this model.

> "These students more often have done nothing of biology since eighth grade, no science at all. There are some issues that are difficult to understand [...], most of all the latest advances [...], **some concepts of biology should be reinforced,** and you have to explain them well”

Teachers’ perception of the subject according to these models and the dimensions that organize them is shown in Figure 1. The dotted lines refer to the teacher who inspired each model and holds a coherent view of it. In contrasts we found that most of the teachers interviewed show an hybrid perception of the subject, with aspects of different models being emphasized in their questionnaires Some interesting views are found, such as T7 is an antagonistic combination where *Epistemic model* in relation to why to teach and what to teach, and the *Academic model* in relation to why, what and how to teach?

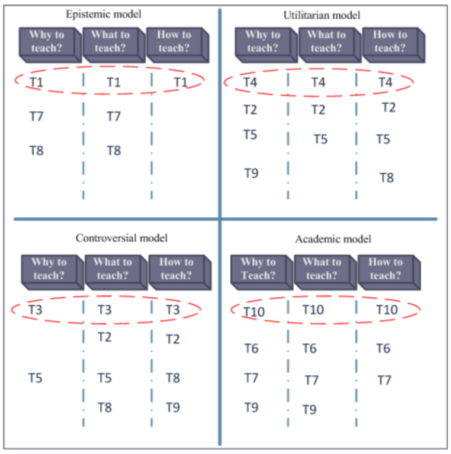

Fig. 1 Models of the subject

Despite its differences, results show that the *Epistemic model, Utilitarian model,* and the *Controversial model*, are all in agreement with the PC. In contrast, the *Academic mode* based on dogmatic traditional view of science and science content and teaching distorts the purpose of the subject and is therefore not consistent with the PC.

CONCLUSIONS AND IMPLICATIONS

Our first conclusion is related to the different ways of interpreting the subject shown by teachers and that different models of the subject coexist. However, some of them are more coherent between purpose, action and content with the PC than others. It is important to remark that there are similar conclusions in other works. That is, the nature of a discipline includes a teacher’s understanding of the history, philosophy, and sociology of the discipline. (Gess-Newsome, 2002). Therefore, the viewpoint of the SCW depends on the teacher's understanding about the nature of the discipline.

From this diversity of perceptions we have identified four models presented and which we can conclude that three of them (Epistemic, Utilitarian & Controversial model) are in agreement with the PC, where each highlights some of the objectives proposed by the PC, while there is a model (Academic model) that distorts completely the objectives of the PC (4/9 teachers). While there are different models, most of the teachers have hybrid viewpoints regarding the subject. In turn we have found that there is general consistency in the teachers' discourse between the dimensions: *why* and *what to teach*? On the other hand, the dimension of “*how to teach*?” can be more eclectic among models, showing the always difficult tension between both knowledge and purpose, and action.

Moreover, we have found that teachers with more didactical resources (mostly those of the IT) implement the subject SCW more coherently with PC than non-innovative teachers. However, this does not mean that being an IT teacher guarantees a coherent model for the subject neither a view close enough to the PC when implementing the subject.

Also we have found that teachers with more didactical resources (mostly those of the IT), are more concerned with their own domain of the knowledge to be taught This is due to the challenge of the subject they realize they have to face, and hence, a lack of knowledge about the content breeds insecurity for teachers to propose new activities (such as debates and role play) and particularly about how to evaluate them.

Finally, despite being an open syllabus, most teachers feel constrained regarding the selection and sequence of contents by structural factors, for example official themes, the textbook, time and lack of knowledge among others.

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MARXISM IN SOCIOCULTURAL PERSPECTIVES AND IMPLICATIONS FOR SCIENCE EDUCATION

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Abstract: Sociocultural approaches to science education originated in Vygotsky"s studies, which were developed under the influence of Marxism. In this paper, we attempt to point out how Vygotsky incorporated the main categories of dialectics in new concepts used to formulate his theory of historical-cultural development. These concepts, used lately as a theoretical framework for much of the sociocultural research and curriculum proposals in science education, are related to social interactions and to the role of language in learning and teaching. However, the Vygotskian project of reforming the psychology based on the Marxist perspective considering the broader institutional forces in human consciousness has not effectively been accomplished. Thus the construction of a sociocultural framework in which social and institutional levels, interpsychological and intrapsychological analysis can be integrated without being reduced to one another remains to be done. In order to contribute to this endeavor, we discuss some educational proposals that are based on dialectical materialism to relate teaching and learning to the concrete conditions of human existence and suggest implications for science education.

Keywords: dialectical materialism, sociocultural perspective, science education.

DEFINITION OF THE PROBLEM

Sociocultural approaches to science education originated in Vygotsky"s studies, which were developed under the influence of Marxism. In this paper we attempt to point out how Vygotsky incorporated the principles of dialectical materialism in psychological intermediate categories that he used to formulate his theory of historical-cultural development. These concepts, used lately as a theoretical framework for much of the sociocultural research and curriculum proposals in science education, are related to social interactions and to the role of language in learning and teaching. However, the Vygotskian project of reforming psychology based on a Marxist perspective considering the broader institutional forces in human consciousness has not effectively been accomplished. Thus, the construction of a sociocultural framework in which social and institutional levels, interpsychological and intrapsychological analyses are integrated without being reduced to one another remains to be done (Wertsch, 1985). In order to contribute to this endeavor, we discuss some educational proposals based on dialectical materialism to relate teaching and learning to the concrete conditions of human existence and suggest implications for science education.

MARXISM AND THE HISTORICAL-CULTURAL PSYCHOLOGY

The analysis presented in this section intends to argue that Vygotsky took hold of the main categories of dialectics (Engels, 1979; Marx and Engels, 2004) to build his cultural-historical theory of human development.In his major works, Vygotsky used the dialectical method to organize the review of the literature of his field producing a synthesis around two extreme and opposed positions such as thesis and antithesis: “all theories range from the identification or fusion of thought and speech, on the one hand, and his equally absolute disjunction and segregation, almost metaphysical, on the other” (2003a, p. 2).

The unit of analysis of any theory that adopts dialectics as the philosophical foundation must be complex, i.e., it must consist of parts and relations of tension between these parties. Thus the strong opposition to the atomistic analysis developed by Vygotsky is not arbitrary. From their commitment to the Marxist dialectics Vygotsky turned to the study of mental processes, "their interdependence and organization structure of consciousness as a whole" (Vygotsky, 2003a, p.1).

The researcher who follows dialectical principles tries to find tensions in the relationship between the parties of the object of study that produce movement, which results in focusing process and history. For Vygotsky, only an historical theory of inner speech can handle the problem of thought and language (2003a, p.190). The following goals are then, necessary: "an analysis of the process as opposed to an analysis of the object; an analysis that reveals the dynamic-causal relations as opposed to listing the external characteristics of a process, i.e., a non-descriptive and explanatory analysis" (2003b, p. 86).

The production of synthesis cannot be considered continuous, since what was there before is qualitatively different from what was produced then. In this sense we can say that the production of synthesis represents a revolution. The notion of mental development to Vygotsky includes the concept of revolution as it happens in terms of fundamental qualitative transformations (Wertsch, 1985).

The Marxist materialism is well recognized in the sentence "it is not consciousness that determines life, but life that determines consciousness" (Marx & Engels, 2004, p. 26). This principle is implicit when Vygotsky postulates that all functions in child development appear twice: first, in the social level and then at the individual level, first between people and then inside the child (Vygotsky, 2003a, p. 64).

MARXISM AND THE SOCIOCULTURAL PERSPECTIVE: AN AGENDA TO SCIENCE EDUCATION

The development of Vygotsky‟s theory taking into account the broader institutional forces in shaping human consciousness was left unfinished, having been limited to the interpsychological processes (Wertsch, 1985). Attempts to expand this framework have been proposed with different directions depending on the theoretical categories emphasized, the social relationships considered and sometimes requiring an interdisciplinary approach.

Leontiev‟s theory of activity (Leontiev, 1982) can be considered an approximation to Marxist assumptions in that it elaborates the implications of labor activity in psychological processes. This theory considers that the activity depends on the situational context in society and elects work as the prototypical form of human activity. This context guides the selection of actions, the operating composition of these actions and their functional significance. An important issue in this framework is how the assumptions implicit in a situational context determine the selection of actions and their operating composition.

Frigotto (1994) relies on the Marxist concept of polytechnic and on the Gramsci‟s idea of „work as an educational principle‟ to reflect on and propose directions to education. He argues that from the last decades of the twentieth century, the introduction of microelectronics in the work process and the correspondent more complex cognitive tasks would require the formation of a new type of worker. In this context, the school should change in order to produce the flexible, comprehensive and polytechnic employees, endowed with understanding of technical and scientific universal principles. The centrality of science in the production process would definitely justify the adoption of work as an educational principle.

Silva (1996) criticizes this proposal demanding more consistency with Marxist principles. In his view, the principle of unity between conception and execution or between intellectual and manual work would be a postulate to be followed in combining work and training and in the goal of training a „polytechnic" man. He maintains that molding education in accordance with changes in the skills required by new technologies used in production relates solely to the content, leaving out the social and political elements involved therein. Furthermore, the author criticizes the rationale that admits a close match between the demands placed by the world of work and the results provided by educational goals, which are central to human capital theory, much criticized by educators in the 80s.

The idea of broader institutional forces in shaping human consciousness has been emphasized recently by sociocultural approaches (e.g., Lemke, 2001), which strengthen the awareness that, in dealing with education, we are dealing with a social, cultural and institutional objects, which would involve the systematic analysis of research and education as institutions politically constituted and subject to the dominant ideologies in a certain time. Lemke (2005) criticizes the political implication of science education in the technical and scientific preparation of the work force and claims that science education has excluded many students by giving prominence to the acquisition of general and abstract principles and moved them away from everyday concerns. The predominance of an ideology that considers abstract learning nobler than practical learning has also contributed to strengthen the emphasis of science education on the acquisition of concepts and its distance from the issues related to social reality. The author advocates a reorientation of scientific education to social issues and problems that must be faced by all humanity in the twenty-first century, as the environmental crisis, social injustice and oppression and injustice to the young.

Analysing how science education is related to macrostructures such as neoliberalism Tobin (2010) concludes that scholars and policymakers have connected the production of knowledge through education to the production of economic capital. For the author, neoliberal social context, especially considering the increasing inequality and the creation of an economic elite oligarchy, has profound implications on science education. From a more critical position, he repudiates the idea that someone can accumulate capital even if it is science learning at the expense of a loss of another"s accumulation and asks how to produce equal learning gains not just equal opportunities to participate, as postulated by neoliberalism.

CONCLUSIONS AND IMPLICATIONS FOR SCIENCE EDUCATION

The criticism of Silva (1996) leads to the conclusion that science education should be reconsidered beyond the scope of changes that teaching and curriculum can provide to the extent that these changes in no way affect the separation between school and work and therefore, the social division of labor that underpins the capitalist model. In this view, recommendations on curricular reorientation in the sense that science education should address relevant issues to the students would not resolve social and educational inequalities. In a structural Marxist and relational perspective of connections between science education and work, the end of educational inequality is a political goal, not an educational goal. In this sense, educators and researchers in science education should encourage critical reflection on these relationships, noting that the conceptual tools of natural sciences are not sufficient, requiring interdisciplinary approaches that connect them to the social sciences. This reflection also cannot disregard the analysis of the broader relations between the production of science and technology and the process of capitalist production.

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A CURRICULUM REFLECTION: NEW SCIENCE AND TECHNOLOGY CURRICULUM IN TURKEY

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Abstract: The goal of the present study was to investigate science teachers' perceptions and reflections over the new science and technology curriculum in Turkey. New science and technology curriculum was based on the constructivist principles, multiple assessment techniques, and many daily life activities. Semi structured interviews with 6 elementary science teachers from 6 different public schools were conducted in Ankara, Turkey. Interview schedule consists of 23 questions and it was organized in 9 themes. These themes are personal information, structure of change, acceptance of change, opinions about the change, feelings about the change, personal accountability for the change, implementation of the change, teacher competency in change, and effects of change on teachers. Additional data was collected through observation forms which include 2 subthemes. According to data analysis, teachers and students are attempting to adapt themselves for their new roles as a facilitator and an active learner. In this context the previous learning experiences of both are an obstacle for the adaptation process. In addition, crowded classrooms, individual differences, socioeconomic status, parents over valuing of grades, physical restrictions, and insufficient in-service teacher training were determined as the main problems of the implementation.

Keywords: Elementary Science and Technology Curriculum, Curriculum Evaluation, Curriculum, Elementary Science Teachers

BACKGROUND, FRAMEWORK and PURPOSE

In 2004, Turkish Ministry of National Education (MONE) began designing a new science and technology curriculum and disseminated new curriculum framework for implementation at the beginning of the 2005 fall semester. There were major changes in the paradigm, philosophy, teaching styles, teacher and student roles, unit organization, etc. The goal of the new science curriculum is to educate children as scientifically literate individuals regardless of their individual differences (MONE, 2004). The new curriculum is based on constructivist principles. There is an emphasis on conceptual learning, active learning and reflective thinking. Within the framework of spiral curriculum, main topics are repeated through the years. Finally, in the new curriculum, there are different assessment techniques such as performance assessment, concept maps, structured grid etc. Many significant changes was started to be implemented with the new curriculum and there are also some studies done as a preliminary results of the curriculum reform (Aydin & Cakiroglu, 2010; Ozturk, Elmas & Savas, 2011). However there is a need to design some other studies related to many aspects of the curriculum reform. Designing the new curriculum with modern educational ideas and paradigms in several cycles is the one side of the coin. The other side, teachers need time, training, activities to support their instructional design, new course books, sufficient subject matter knowledge and a paradigm shift in their pedagogies, and belief and value systems. Because there is mostly a gap between what was written on the curriculum and what was implemented in the classroom (Shkedi, 1998).

The purpose of this study is to determine the early evaluation of elementary science teachers' opinions and perceptions related to the new elementary science and technology curriculum and their transfer of the new reform ideas into their classroom practice.

RATIONALE

Teachers and students are producing their own curriculum realities in the classroom rather than following curriculum prescriptions. So, key actors in the design are the elementary science teachers since their awareness about the curriculum is crucial (Roehrig, Kruse, & Kern, 2007). To make permanent impact on the educational system, early evaluations of the new curriculum are of critical importance, in the direction of determining weak and strong points. The curriculum should be improved and redesigned at the unsatisfactory points continually.

RESEARCH QUESTIONS

1. How do public elementary school science teachers perceive the new curriculum?
2. How do public elementary school science teachers transfer curriculum changes to their classrooms?
3. What are the elementary science teachers' concerns about implementing the new curriculum?

METHOD

This is a phenomological study (Marshall & Rossman, 2006), which mainly focused on capturing the meaning of lived experiences of elementary science teachers' about the implementation of the new curriculum. In this research, a two-step sampling process was used while selecting the participants; a typical case and maximum variation sampling. Six schools which are chosen for the study are representative of average public schools in Turkey. In the second step, 6 elementary science teachers were selected from these schools. Any common experiences of elementary science teachers that emerge from great variation of years of experience are of special interest and valuable in capturing the core patterns, shared beliefs and different point of views.

A semi structured interview schedule lists the questions for the sake of ensuring the same style of query is pursued with each interviewee (Patton, 2002). All the interviews were tape recorded with the consent of teachers and were transcribed verbatim. Interview Schedule consists of 23 questions and it was organized in 9 themes. These themes are personal information, structure of change, acceptance of change, opinions about the change, feelings about the change, personal accountability for the change, implementation of the change, teacher competency in change, and effects of change on teachers. Additional data was collected with observation forms which includes 2 subthemes. These subthemes are the portrayal of the school and description of the classroom. Portrayal of the school theme consisted of 11 questions and description of the school theme consisted of 5 questions.

In addition, inductive content analyses were applied to analyze the transcriptions of interviews and observations. To be confident about the codes and themes, 3 researchers in the study coded all six interviews and observations by themselves and series of meetings were arranged to ensure inter coder reliability (96%) and the objectivity of the study. In this study, we assured credibility of the data by using method and analyst triangulation. We gathered data from interviews, observations and from documents (new curriculum program book) to achieve source triangulation. We ensured the analyst triangulation with working as a team of researchers (three) in the analysis processes. Peer debriefings involved formal and informal discussions with other researchers for finding alternative explanations and checking the emerging themes and design (Miles & Huberman, 1994). In order to establish transferability, thick and detailed descriptions of the characteristics of the setting, sample, and the processes were provided.

RESULTS

Structure of change

The change in the curriculum was vital in this reform; however, teachers' beliefs about these changes have an important role in their practice (Anderson, White and Sullivan, 2005). Therefore, teachers were asked questions about the nature of the change to reveal their beliefs. According to teachers the change in rationale is the most important change in the curriculum. Teachers emphasized the student-centered instruction as one of the most important thing bringing with the new curriculum. Teachers are not source of knowledge anymore; instead students construct their own knowledge. About this issue, teacher II stated that,

> "The rationale of the curriculum has been changed totally. Now, students interpret the knowledge and obtain the knowledge by themselves."

Both teachers and students are active and creative in the curriculum. Moreover, teachers are just facilitating the classroom instruction while students are independent learners. Another important change mostly stated by teachers was the activity oriented nature of the curriculum. However, teachers interpret the activities in different ways. Teacher II did not mention any difference in learning activities. Teacher II stated that,

> "Some of the experiments in the previous curriculum were named as activity in the current one. They are now performed both in and out of the laboratories."

Other teachers mentioned about the change in both the quantity and the nature of the activities. Some teachers mentioned the ease of performing them without any time or material problem although some of them listed the material finding as an obstacle in implementing the new curriculum. Besides, teacher III considered the games and activities as incentives for convincing students to learn.

While all the teachers pointed out the shift from the assessment of rote learning with open-ended and multiple-choice questions to multifaceted assessment with different tools such as rubrics, concept maps, performance assessment and structured grid; teacher II, and teacher III complained about the assessment of project based assignments. Teacher III expressed her complaints with the following words,

> "I think project based assignments are normally effective but they turned out to be a responsibility for parents rather than students. Students and parents focus on high grades and if students get low grades, parents feel unpleasant about the outcome and come to school to criticize me about the low grades. Therefore, project based assignments become an issue concerning the families now. Project based assignments are an issue when parents have to spend time and money."

All the teachers think that textbooks are simplified in terms of content, and they are full of activities and questions. However, teacher II criticized the textbooks in terms of figures and content load and gave the meiosis figure as an example that causes confusion in students' mind. Most of the teachers stated that they prefer not to use the traditional methods by making students more active in learning the process. Teacher IV and teacher V issued that their teaching style did not changed so, since they have already using student centered learning activities. These teachers are both the youngest teachers and the teachers who are enrolled in a graduate program. On the contrary, teacher III, who has the most teaching experience, stated that he could not change his teaching style due to his previous experiences.

Acceptance of change

In order to decide the teachers' acceptance of change we investigated their use of program book. We asked how frequent and for what purposes they use program book. When we analyzed their answers, we realized that the answers of teachers, interestingly, have a relationship with the teaching experience of the teachers.

Teachers with least experience (5 and 6 years of experience) do not prefer to use program book regularly while teachers with the most experience (23 and 31 years of experience) use it to follow the objectives and topics to be taught and the teachers with medium experience (11 and 17 years of experience) follow the program book when planning their lessons. Most of the teachers found the new curriculum understandable but have doubts about its usability in Turkish context.

Opinions about the change

The general opinions of the teachers about the change can be summarized as in Table 1.

Table 1. "General Opinions of Teachers about the Change"

	Teacher I	Teacher II	Teacher III	TeacherIV	Teacher V	Teacher VI
Content load	Sufficient	Sufficient	sufficient in 6th and 7th grade	sufficient in 6th and 7th grade, more intense in 8th grade	Intense	Intense
Spiral curriculum	Admire	Discontinuities	Need more time for repetitions	Admire	Admire	Admire
Daily life connection	Admire	Admire	Admire	Admire	Admire	Admire

Teachers are generally pleasant with the change in content load which is far less than the previous curriculum. However, when implementing the new pedagogies and ideas, teacher V and teacher VI have some problems in covering all the objectives due to intense content load. Moreover, teachers have positive opinions about the spiral nature of curriculum organization except the ones who complain about the difficulty and discontinuity between the repetitions of the topics throughout the years. Daily life examples in the textbooks are relevant both for teachers and students.

Feelings about change

Teachers feel happy about implementing the new pedagogies in their classrooms. Moreover, teachers feel sufficient in implementing the new curriculum especially when they get positive feedback from students. However, teacher II reported that he feels unsatisfied with the curriculum. The following sentence includes her reason for this;

> "I feel unsatisfied in my new role in the curriculum. I feel as if I am supposed to teach them more and more."

Almost all of the teachers have positive feeling about implementing the new curriculum. Their new role in the curriculum or using new pedagogies and paradigms did not cause much discomfort on them.

Personal accountability for the change

Teachers were asked about trainings they got about the new curriculum as an indicator of personal accountability for the change. Moreover, they were asked about what are the teacher responsibilities in the curriculum to determine how much they perceive themselves responsible.

Teachers generally complained about the lack and insufficiency of the teacher training organized by the ministry of education. Only teacher V did not complain about this deficiency. Because he worked in the school in which the new curriculum was piloted before dissemination. They learned the new curriculum by reading or participating to other training courses. Teachers consider participating training courses, willingness, acceptance, mastery in the content and model, preparing activities, open-mindedness, recognizing class as important responsibilities in implementation of the curriculum.

Implementation of the change

All the opinions and feelings of the teachers mentioned above affect their implementation of the new curriculum because the beliefs and knowledge of the teachers about the curriculum mediates the adaptation to the reform (Gess-Newsome, Southerland, Johnston and Woodbury, 2003; Pajares, 1992). Therefore, we asked them to learn about how they implemented and what kind of difficulties they encountered in implementation along with their opinions and feelings about the curriculum change.

When planning their first lessons with the new curriculum, teachers tried to find different activities, games and materials from web or books. In this phase, none of them got assistance from their colleagues, but they used the documents of Ministry of National Education (MONE), web and got help from some academicians. When teachers were asked the factors affecting their implementation of the new curriculum, all of them complained about the families. They stated that parents are unaware of the new curriculum and they suffer from the tasks their children are given. Each teacher mentioned the neutrality of the school administration, but some of them mention they need to be reinforced and be provided trainings.

Teacher competency in change

All teachers feel sufficient themselves in content knowledge except teacher one who feels insufficient in pedagogical content knowledge and content knowledge. Teacher II defended his insufficiency as;

> “I feel myself insufficient in subject matter knowledge because the science content is very broad. I am insufficient in biology, especially in meiosis, chromosome number change. I feel myself insufficient in science also because of tentative nature of science and technology.”

Teacher II and teacher V feel themselves insufficient in activity preparation either because of time restriction or lack of knowledge on how to do some experiments and activities. Teacher IV is the one who thinks that student-centered education is applied in her classroom. She described her classroom environment a bit noisy but warm and kind. Other teachers blamed physical settings, students’ insufficient background, mainstreaming students, crowded and unmotivated classrooms, diversity in discussion skills of the students, noise and seating arrangements for failing the implementation of student-centered education.

Effects of change on teacher

Curriculum change has caused some changes on all teachers to some extent. Some of them said that they changed drastically in terms of their perspectives, teaching styles, research habits. Others said they had chance to have new and interesting experiences whereas. Only teacher III mentioned no change with curriculum change.

> “There is no change at all. The only thing changing is the tools we use, not anything else. The blackboards became whiteboards.”

This quotation shows the beliefs of the teacher about the change in curriculum. Teachers' beliefs rather than their knowledge have effect on their decisions in curriculum implementation (Pajares, 1992). It is clear from the previous sections that the routines or practices did not change so after the curriculum reform. There is not a change in this teacher's decisions in implementing the new curriculum because of his core beliefs.

After presenting the results theme by theme with quotations, positive and negative viewpoints of the teachers about the new curriculum can be summarized as in the table below.

Table 2. “Viewpoints of Teachers about the Curriculum Change”

Positive Viewpoints	Negative Viewpoints
1. Decrease in the content load is the most important change. 2. Teacher is active and creative but the instruction is student-centered, the new role of the teacher is facilitator instead of instructor. 3. Students are more active and independent in the new curriculum. 4. New curriculum is more activity-oriented; lessons are designed as promoting knowledge construction of students. 5. The current curriculum requires the use of different assessment techniques such as performance tasks, project assignments, presentations. 6. Textbooks are simplified in terms of content load and they are more attractive for students. 7. Teachers are more proponent of the use of new pedagogies to make students more involved in learning process. 8. Teachers pointed out the usefulness of the spiral structure of the content organization.	1. According to teachers project based assignments became an issue concerning family, especially when parents are obliged to spend time and money to these assignments. 2. Although many teachers have positive opinions about the spiral curriculum, some teachers complained about the difficulty of and discontinuity between the repetitions of the topics throughout the years. 3. Teachers feel insufficient in activity preparation. 4. Implementation of the student-centered instruction is challenging because of physical setting, individual differences and classroom management problems. 5. New paradigms could not be internalized by parents, students and teachers in such a limited time span. 6. The workload of teachers is intense in the new curriculum. 7. Teachers demanded more support and encouragement from the administrators in the curriculum implementation process.

Observation forms

The schools, in which teachers work, were also observed in order to get an idea about the portrayal of the school and to describe the classroom. Schools were chosen from different district, but they were all in similar environments. All of the students have garden that ensure place for out of class activities. The schools also have computer laboratories, although some of the schools do not have science laboratories. There are about 1 to 4 science and technology teachers in the schools. Therefore, most of teachers have chance to collaborate with the teachers from their field.

In the classrooms whiteboards are used. There are also projectors in some classrooms. The classroom sizes are average and the seating arrangement is classical and the classroom sizes are not convenient for changing the seating arrangement flexibly. As teachers stated the classrooms are not suitable for student-centered instruction. They were designed more for lectures which is teacher-centered.

CONCLUSION and IMPLICATIONS

A major problem in Turkey is that curriculum reforms are espoused with overly big innovation ideas within unrealistically short timelines and with very limited economic investment in human resources (especially teachers) and supportive materials. In addition, there is a lack of organization and coherence between system components. In the design phase, involvement of all stakeholders of the system often neglected and the whole curriculum was designed with a small group of stakeholders. These deficiencies foster the retention of old methods and practices despite the new curriculum implementation efforts.

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BECOMING A SCIENTIST MEANS BECOMING A CITIZEN

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Abstract: Science education in every democratically governed society faces the same dilemma: that of catering in the same classroom for the intending science specialist and the future citizen (lay-person). This paper is concerned with the science education of the intending scientist.

The idea that science education in the compulsory years of schooling should be accessible to all students has driven science education in the developed world since at least the 1980s. In the focus on an appropriate science education for a citizen, the education of scientists has gone largely unexamined; however, the majority of science curricula developed for all students bear a remarkable similarity, across the years and across societies, to those developed in the immediate post-war period for the education of intending scientists.

I argue that today's social climate requires a new vision for the science literacy and the social understanding of the next generation of expert scientists. This is an approach that explicitly re-frames the intending scientist as both a scientist and a citizen. If we adopt this view it becomes clear that STS/Science for All curricula, once regarded as solely for the layperson, are indeed appropriate for all citizens. I illustrate the argument by considering aspects of the account of science given in Australia's new, first, national curriculum.

Keywords: science curriculum, secondary school, science literacy, science for citizens, science curriculum in Australia.

INTRODUCTION: THE PROBLEM

Science education in every democratically governed society faces the same key dilemma: how does one cater in the same classroom for the intending science specialist and the future citizen (layperson). This paper is concerned with the science education of the intending scientist. I argue that today's social climate requires a new vision for the science literacy and the social understanding of the next generation of expert scientists. This is an approach that explicitly re-frames the intending scientist as both a scientist and a citizen

The argument I present below comprises two key strands. The first is a brief account of recent trends within science education; the second is an account of a socio-political perspective that calls for a post-patrimonial approach to the education of intending scientists.

CONTEXT AND THEORETICAL POSITION

The underpinning theoretical position for this paper is that curriculum "functions to initiate pupils into the cultural, economic and political life of their society" (Carr, 1993, p. 1); the study of curriculum should help us to see how it "operates to transmit, sustain and contest the ideologies and social structures of society" (ibid). I deal here with the words written in curriculum documents rather than an enacted curriculum because my concern here is with formal policy intent as it is expressed through such documents. As Carr reminds us, "political questions about how society ought to be changed and improved always give focus and direction to curriculum questions about what should be taught and learned" (Carr, 1993, p. 1).

To some extent the position I adopt here derives from my location in Victoria, Australia. Australia has a federal system of government in which power is divided between states and Commonwealth Government. The states retain control over key areas, including police, hospitals, public transport and school education. Each Australian state has developed its own education system that differs from the others in a variety of ways: students begin school at different ages, school holiday dates do not coincide, and each state has its own school curriculum.

Although the Commonwealth Government nominally has no authority over school education, it has gained influence through providing funding, a process that began in the 1950s and 60s with Commonwealth grants to finance modern science laboratories in secondary schools. The Commonwealth Government has negotiated an agreement with the various states and relevant territories of Australia to develop a national curriculum, called The Australian Curriculum. When implemented, this will be Australian's first national curriculum. Science remains a key area of interest for Commonwealth Ministers of Education, and Science was one of the first subjects for which the Australian Curriculum was written. The policy context and politics of its development are outside the scope of this article.

TRENDS IN SCIENCE EDUCATION

The period after World War II saw substantial investment in science education. Several significant science curriculum projects were developed in the 1960s and early 1970s, largely aimed at senior secondary school science students: PSSC Physics (Physical Science Study Committee, 1960) was the first such project. The authors of these projects hoped to tempt the best students study science: the courses they produced were, largely, a preparation for further study in science. To some extent this was a continuation of the historical role that science has had in formal schooling.

The 1970s brought substantially increased student retention into the senior years of secondary school (Fensham, 1992): the idea that science education in the compulsory years of schooling should be accessible to all students, not just those who would continue to study science, has driven science education in the developed world since at least the 1980s. The focus has been on what might constitute an appropriate science education for a citizen. The consequent innovations in science curriculum can be thought of, broadly, as deriving from three emblematic international movements in science education: Science Technology and Society (STS), Science for All and scientific literacy. The most current of these ideas is that of scientific literacy or science literacy (Roberts, 2007). However, internationally, there was some disagreement as to whether a broad, socially relevant science education should be made available as the only offering or in parallel with the existing narrower formal system. This second formulation would see intending scientists continue with their preparation for further study while the 'layperson' would take 'Science for All' courses.

In Australia, almost from its inception, the Science for All movement saw the needs of the 'layperson' as different from those of the intending scientist (Fensham, 1985). Intending scientists were largely seen as a separate group and effectively exempted from the sort of science education deemed necessary for the future citizen. Further, because the science courses designed for intending scientists could be seen solely as a preparation for further study in science, these courses tended to teach a traditional and de-contextualized version of science. At the same time, views of inclusivity and access meant that it was also commonly held that every child should be allowed the chance to proceed to future studies in science. Thus, because Science for All/STS was not seen as appropriate preparation for intending scientists, any student who thought they might want to continue with science took the courses intended for future scientists.

Today, the accrued effect is that in many societies, including Australia, our vision for the scientifically literate citizen has become restricted to that of a participant in a scientifically literate workforce, and our vision for that workforce is largely framed by the traditionally perceived needs of academic scientists. Roberts (2007) describes this as Vision I for scientific literacy: a vision that looks to the canonical science of the academy for an account of what should be taught in schools.

I argue here that we require a fresh approach that explicitly re-frames the intending scientist as both a scientist and a citizen. If we adopt this view it becomes clear that the STS/Science for All curricula - once regarded as solely for the layperson - are indeed appropriate for all citizens. I give one example to illustrate this approach and then consider the extent to which the approach is supported by Australia's new, first, national curriculum in science.

A POST-PATRIMONIAL APPROACH TO EDUCATING FUTURE SCIENTISTS

Throughout the developed world, the social climate today requires a new vision for the next generation of expert scientists. I offer two warrants for this claim: the first is that science is a complex socially embedded institution which both shapes and is shaped by the societies in which it is practised (Aikenhead, 1994, 2006; Berger & Luckman, 1967; Chalmers, 1990; Charlesworth, Farrall, Stokes, & Turnbull, 1989; Kuhn, 1970; Latour & Woolgar, 1979); the second utilizes a social perspective put forward by the political theorist Anna Yeatman (Yeatman, 1997, 1998, 2000). I present a brief summary of this perspective below: more detailed accounts of this argument can be found elsewhere (Smith, 2006, 2011b; Smith & Gunstone, 2009).

The most significant social trend in the developed world over recent years has been the trend towards marketization. This trend has been accompanied by a substantial alteration in the relationships between citizens - now framed as consumers - and society in the broad. Critiques of science curriculum in schools frequently call for an updating of content and methods to reflect the substantial technological shifts that have taken place since the 1970s, and such updating is certainly needed. However, we should also examine the impacts of the shift to neo-liberal market driven priorities on the relationship between scientists and society. Studies of the public engagement with science document a gap between the needs of the community in the broad and the support that science is able to provide (Feinstein, 2011; Layton, Jenkins, Macgill, & Davey, 1993; Roth & Lee, 2002). Perhaps the best description of this gap comes in the choice of Layton and his colleagues to title their study 'inarticulate science'.

The word 'articulate' has two meanings. In its oldest sense it means to express oneself fluently or to speak clearly. Its other sense is to be jointed. The Layton report has been frequently cited in its first sense: "the formal language of science needs to be translated if it is to be accessible to ordinary citizens" (Fensham, 2002, p. 17). However, the way that Layton and his co-researchers use the word suggests that they intend it to have both senses: "there is a lack of articulation between the scientific notion of energy … and the understandings which elderly people invoke …" (Layton et al., 1993, p. 74). This is a richer usage than merely to speak clearly: one may speak very clearly but still not address the needs of one's audience. To call for articulation in the other sense is to directly address a need for flexibility on the part of science as it makes connection with 'the laity'.

Such flexibility is essential today because science professionals - indeed, all professionals - are faced with a need to establish with the laity a different relationship from the one that has sufficed until now. In the immediate postwar period governance was modeled along patrimonial lines, experts knew what was best and the laity followed their advice. Today we live in a neo-liberal, post-patrimonial climate: the dominant forms of governance in the developed world today give primacy to the rights and needs of each individual, and see social order as being brought about by the processes of a market (Apple, 2006; Ball, 2006; Marginson, 1986, 1997). Today, "[t]he older patrimonial economy where the householder owes protection to his dependents has gone" (Yeatman, 2000, p. 184): it is no longer appropriate that an expert assume the authority to speak for the layperson and instead the layperson expects to have a voice and be allowed to choose for themselves.

The usual response to today's altered circumstances is to ask that the ordinary citizen gain a substantial expertise in science, so that he or she might make responsible choices. Generally the science that is recommended is the canonical science of the academy. However, there is another response to the demand for a post-patrimonial relationship between experts and the laity: to see the role of the expert as supporting and enhancing the voice and choice of the ordinary citizen. I argue that this second approach is essential for the wellbeing of both the institutions of science and society in the broad (Smith, 2006).

If scientists are to operate successfully in a post-patrimonial society, they must have a grasp of the social context of science and better articulate their work within this social context. Scientific literacy should be seen as a process of a community rather than an attribute of an individual (Roth & Lee, 2002) more akin to Roberts' (2007) Vision II. Further, the place to first adopt such an altered view is in school classrooms: it is here that an insistence that the laity needs a sound grounding in canonical science has proved a block to a Science for All curriculum. Curricula such as 21st Century Science (Millar, 2000, 2006) are a significant movement in this direction.

WHAT MIGHT SUCH AN APPROACH LOOK LIKE IN PRACTICE?

Curriculum provides guidance about what should be taught in three key ways: it specifies what should be taught, what account should be given of the content, and to what end. If we keep in sight the view that an intending scientist is also a citizen, then perhaps the easiest and yet the most powerful first step is to attend to the account that we give of the science we teach. Corrigan and Fensham (2002) tell of the ways in which the canonical chemistry of acids and bases is transformed by the different accounts given by teachers in three different vocational education settings: nursing, lithography and winemaking. I offer an example here taken from my own practice as a schoolteacher at an academically oriented school before examining the account of science given in the Australian Curriculum.

Teaching Variation and Natural Selection

There are at least three ways that I can see to teach the ideas of variation and natural selection. The first involves a study of the fossil record, the second is to explicitly contrast the scientific account of evolution with creation stories from various cultures and religions, while the third is to teach about the development of antibiotic resistance in bacteria. All of these approaches involve teaching roughly the same science content knowledge: the first and the third also allow a range of experiments. In my time as a science teacher I have worked with my colleagues to try all three approaches, and have come to the view that the first approach is useful in Primary school and up to Year 8. The second approach allows for interesting debate, but it does show science in conflict with society in a way that can be unproductive for learning science. The third approach, on the other hand, is a powerful way to teach these ideas in Years 9 and 10 because it deals with an issue of immediate relevance to all students; of the three approaches described here, the third allows perhaps the most complex account of science and its processes, and it also gives students an area in which they can choose how to act. Not every student will grasp all the details of how bacteria develop antibiotic resistance – the science here is complex enough to challenge the most able students – but every student does come to understand that how he or she deals with antibiotics is important and has consequences for all of society.

As teachers, my colleagues and I were able to make a choice of how to approach teaching these ideas because the curriculum framework that we had at that time gave us these choices. However, whether Australian teachers will continue to be allowed such flexibility is not clear (Smith, 2011a, 2011b). Below I consider whether the Australian Curriculum for Science allows or facilitates different accounts of science congruent with the post-patrimonial approach that I have outlined in this article.

THE AUSTRALIAN CURRICULUM FOR SCIENCE

Science in the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2011) is organised in three strands: Science Understanding (SU), Science as a Human Endeavour (SHE) and Science Inquiry Skills (SIS). Science Understanding has four familiar sub-strands: Biological sciences, Chemical sciences, Earth and space sciences and Physical sciences; Science Inquiry Skills comprises five sub-strands that have to do with developing hypotheses, designing experiments, collecting and analysing data and evaluating and communicating the outcomes; Science as a Human Endeavour comprises two sub-strands: Nature and development of science and the Use and influence of science.

> In the practice of science, the three strands of Science Understanding, Science as a Human Endeavour and Science Inquiry Skills are closely integrated; the work of scientists reflects the nature and development of science, is built around scientific inquiry and seeks to respond to and influence society's needs. Students' experiences of school science should mirror and connect to this multifaceted view of science.
>
> To achieve this, the three strands of the Australian Curriculum: Science should be taught in an integrated way. (Australian Curriculum Assessment and Reporting Authority, 2011)

It seems reasonable to expect, then, that teachers will be supported in giving an account of science as a social institution. However, there are some other aspects of the curriculum that will undercut this possibility. The curriculum is developed around six overarching ideas that "support the coherence and developmental sequence of science knowledge within and across year levels". These ideas are framed to support the Science Understanding and Science Inquiry Skills strands, and they "contribute the development of students appreciation of the nature of science". There is no suggestion that they might support students' development of understanding of the use and influence of science in society: in other words, the overarching ideas are likely to support a canonical account of science. At each year level the various strands and sub-strands are elaborated into Content Descriptions and Achievement Standards. What is noticeable here is that there is substantial content and that, while it might be possible to adopt a variety of approaches, only one such approach is well supported by the materials provided within the curriculum.

This curriculum will form the basis of national testing in science: whether the tests will allow for a variety of approaches is not yet clear. One indicator of whether variety will be supported is what the curriculum has to say about diversity. The Australian Curriculum asserts that it "has been developed to ensure that curriculum content and achievement standards establish high expectations for all students. Every student is entitled to enriching learning experiences across all areas of the curriculum. Students in Australian classrooms have multiple, diverse and changing needs that are shaped by individual learning histories and abilities as well as cultural language backgrounds and socio-economic factors". However, only two groups are explicitly considered in detail: students with special education needs and students for whom English is an additional language or dialect. It is disappointing that the authors of this curriculum acknowledge the multiple, diverse and changing populations of Australia yet do not make a more explicit provision to support a diversity of approaches. They leave canonical science as the clear supported option.

CONCLUSION

A curriculum for the intending future scientist should present Science as the work of people with the full range of human faults, passions and perspectives, working as communities. All aspects of Science should be seen as socially embedded, inextricably linked with the communities in which Science developed and in which it is now practiced. A science curriculum should facilitate the development of articulate scientists: communication in appropriate and easily accessible terms should be seen as the normal work of science professionals and the science content should be taught in a relevant, appropriate and engaging social context. The new Australian Curriculum for Science might allow these things to happen, but it does not give a strong indication of supporting them.

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TRANSFER OF A TEACHING-LEARNING SEQUENCE FROM GREEK TO ITALIAN SCHOOL: DO SIMILARITIES IN EDUCATIONAL SYSTEMS REALLY HELP?

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Abstract: The specific purpose of this paper is to investigate the changes that occurred in the process of the transfer of a Teaching-Learning Sequence (TLS) from the designer's to a host's context. Besides we discuss if the similarities between educational systems may actually favour such a transfer. The specific case concerns the transfer of a TLS on thermal properties of materials from the Greek educational context into Italian one. The research has been framed in the "*Adaptation* and *Re-Invention"* (ARI) theoretical model. According to this model, some "core" elements of the original TLS, namely, scientific concepts addressed, pedagogical approach adopted, ICT-enhanced aspects and the activities' sequence, have been first identified and then adapted for the new context. The resulting new core elements of the transferred TLS have been compared with those of the original TLS to investigate about the feasibility of the transfer. Results show that the similarities between the two educational contexts acted mainly as facilitators of the transfer process. Moreover, direct communication and interactions between the involved groups and an external expert helped significantly the process. Data from implementations in the two educational contexts show also similar positive effects on students' learning outcomes.

Keywords: Teaching-Learning Sequences; Knowledge transfer; Heat conduction

BACKGROUND, FRAMEWORK AND PURPOSE

Exchanges of successful educational practices and artefacts have become one important issue for debate within European Union. Despite the interest and profound educational and political implications, research studies devoted to document and reflect upon efforts to disseminate successful practices amongst different countries are rather scarce at least in Science Education. In this paper we address this issue in terms of a case study involving the transfer of a Teaching-Learning Sequence (TLS) (Meheut & Psillos, 2004) about heat conduction, originally designed by a group of researchers and experienced teachers located in the Department of Primary Education Aristotle University of Thessaloniki for compulsory lower Secondary Schools, Gymnasium (13-15 yrs students), into the corresponding Italian school level (14-15 yrs students).

The Italian and Greek educational systems are both centralized; the curriculum is compulsory and established at national level. In both countries, science teaching shares some other important characteristics as, for instance, the low diffusion of hands-on laboratory and ICT based activities and the lack of habits of inquiry teaching on behalf of teachers. Moreover, concerning the scientific contents addressed in the curriculum at lower secondary school level, basic aspects about heat and temperature phenomenology, heat conduction and some ideas about the matter structure, e.g., atoms and molecules, are addressed in both countries.

The specific purpose of this study is therefore to investigate to what extent such similarities between the educational systems of the two Countries have favoured the transfer of an educational practice which has been proved to be successful in the original context. In particular, the specific research questions that guided this study are:

RQ1) was the original TLS changed in the process of transfer in the new context?

RQ2) what were the similarities between the educational systems that favoured (or influenced) the embedment of the original TLS in the new context?

RATIONALE

A simple way to transfer knowledge organized in the form of a TLS would consist in a unidirectional adaptation from the original educational context to the host one: this linear process would occur mainly when TLSs are edit in such a format that makes difficult any flexibility. However, previous studies in Science Education (Pintò, 2005) have shown that TLSs, in particular those aimed at innovating usual teaching habits, cannot simply transferred from the original designers to the users (scholars, teachers, …) but re-made, re-constituted, and re-structured. To put it simpler, the actions that will take place in order to adapt the original teaching proposal to the context in which it will be actually implemented are unavoidably transformative. Hence, from a general perspective, knowledge transfer of a research-based TLS is not an unilateral process from a developer to a passive receiver since a TLS necessarily involves both explicit artefacts containing formal knowledge and tacit knowledge related to designing and implementing it.

To take into account the complexity embedded in the TLS transfer process, we opted to frame this study into the "*Adaptation* and *Re-Invention"* (ARI) model (Rogers, 1983). Within this model, a basic transfer process consists in a bi-directional communication between two main "actors", namely the original knowledge producer and the host one. During the communication process, the two actors reach a consensus about the adaptations and refinements that the original product must undergo in order to fit the host context (Figure 1).

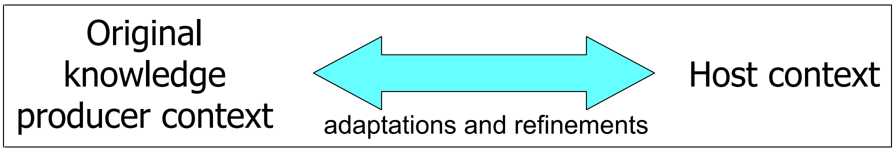

Figure 1: graphical representation of the basic ARI model (Rogers, 1983)

In the case of the transfer of a TLS, we conceive the process as an interactive cycle consisting in a de-contextualization of the original implementation procedures, the identification and adaptation of general "core" ideas embedded in a TLS, and a re-contextualization in the new setting (Figure 2).

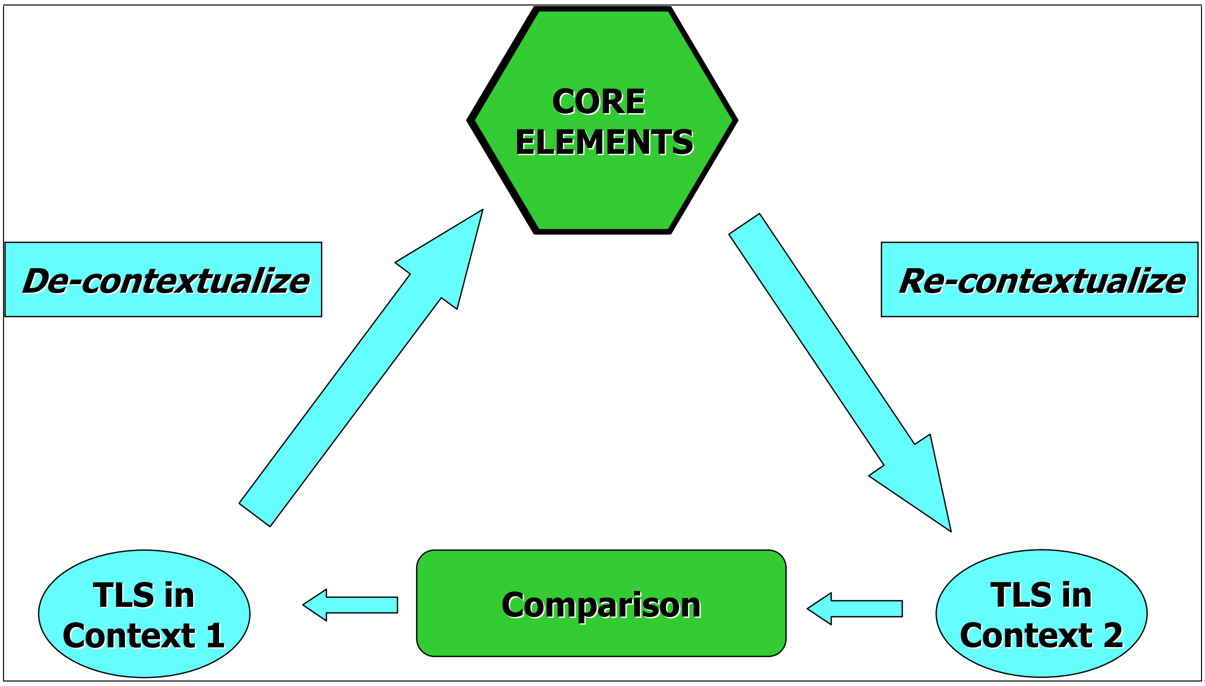

Figure 2: graphical representation of the modified ARI model to frame TLS transfer process

Briefly speaking, we suggest that the core ideas of a TLS materialize in specific elements concerning the scientific concepts and models addressed, the pedagogical approach used in the activities, and some ICT-enhanced aspects. Not all elements in original TLS are core ideas, of course: for instance, some specific activities or particular experiments cannot be included in the core, unless they are considered essential for the conceptual sequence of the overall TLS. The envisioned process is essentially research driven: data (original and host designers' views, involved teachers' actions and ideas, students' achievements) are collected in both contexts during the overall transfer process. In particular, content analysis "in retrospective" of the data collected in the host context allows to compare if the core elements of original context in the re-contextualization phase have been modified, kept or removed. Possible factors that have favoured or hindered the transfer can in this way be reliably identified. Within the proposed modified ARI model, the original TLS is therefore transferable if the whole process does not affect radically its core elements.

For the specific case reported here, the TLS to be transferred was aimed at the understanding of scientific concepts and models related to heat conduction and thermal properties of materials (Hatzikraniotis et al., 2010). Proposed teaching units are based on the Predict-Observe-Explain (POE) strategy (White & Gunstone, 1992) and are aimed at familiarizing students with scientific inquiry, specially improving their capability to design experimental investigations, to verify or reject a hypothesis and to become familiar with the use of experimental evidence. An ICT enriched learning environment is adopted to exploit didactically reconstructed microscopic representations which depict thermal interactions in iconic, graphic and symbolic forms. During the TLS activities, students work in groups, solve problems, and are engaged in classroom discussions with the aim of constructing links between evidence and explanations. The main "core elements" of the original TLS are resumed in Table 1.

Table 1. Core elements of the original TLS on heat conduction

Core Element	Description
Pedagogical approach	Guided inquiry Experimentation from teacher led towards more open investigations, Application of POE strategy based on autonomous group work Design of experiments by students Meta-cognitive reflections within units and overall at the end of the TLS
Modelling	Deductive use by students of simulated microscopic teaching models for visualizing and interpreting temperature and thermal conductivity. Engagement of students to guided explorative modelling activities and reflections on the nature and scope of scientific models.
Scientific concepts	Heat and temperature, heat conduction in materials, behaviour of thermal insulators and conductors (ceramics and metals), microscopic model of matter, factors affecting conduction
ICT	Use of simulated microscopic models of temperature change and thermal conduction in ceramics and metals Use of a virtual laboratory and simulated Flash-based experiments
Other aspects	Combination of virtual and hands on experiments Use of exemplar experiments on thermal conduction in metals Interplay of macro- with micro-processes, conductivity in containers and bars Thermal insulation of a house

METHODS

The transfer process was designed as following. The original developer of the TLS, the Greek group, prepared and provided the host partner, the Italian group, with a “background” document including, in concise form, the formal knowledge of the artefact, contextual information, the specific school settings, relevance of TLS with the local curriculum, and information about the design and implementation of TLS, namely, design principles, the pedagogical approach, the methodological framework, the student assessment tools and the procedures used to apply the TLS. Then, internet based communication (e-mails exchanges, file sharing, etc…) followed, with the aim of enhancing interactions and mutual understanding between the two groups. As a third step, the Italian group prepared a new background document in which information about the educational context where the TLS would have been implemented and the adaptations carried out were provided. Comments and reflections were also given as a sort of feedback to the original designers. As a forth step, two “study visits” followed, involving both developer and host groups experts. One external expert also participated in both visits. Each visit lasted one week and was aimed at analysing the process of implementation and validation of the TLS in both educational contexts. During the visits, at least one implementation in a real school context occurred and data were collected, including for this specific case: experts’ observation notes; interviews with local teachers and students; notes on discussions between researchers and the external expert, students’ pre- and post-questionnaires. As a fifth step, after each visit, the visiting experts prepared a report on the basis of the data collected during the visit, so to give feedback about the feasibility of the TLS to the original designers and about the effectiveness of introduced changes to the partner that adapted the TLS.

The primary source of data for this study were the background documents and the study visit observations, discussions and reports as well as some students' learning outcomes. In particular, evidence to investigate the feasibility of the TLS transfer was drawn from the comparison between the core elements of the original and adapted TLS, resulting in the identification of those elements that have been more easily adapted or transferred from one educational context to another, as well as of favoring and hindering factors.

FINDINGS

The main adaptations introduced by the Italian group and their justification/interpretation are reported in Table 2, according to the adopted core elements analysis.

Table 2. Core elements of the transferred TLS on heat conduction

Core Element	Description (D) and justification (J) of the change(s)
Modelling	*D.* Additional use of mechanical analogies for justifying particle interactions in ceramics and metals *J.* To facilitate students' interpretation of the heat transfer mechanism
Scientific concepts	*D.* Quantitative relationship amongst the factors influencing thermal conduction *J.* The formalization seemed necessary because Italian textbooks at lower secondary school level usually formalize physics laws in a mathematical way. Moreover, it is usual to collect experimental data to prove studied laws
Other aspects	*D.* Changes in the conceptual sequence, e.g., *a)* problematic situation about house insulation addressed at the beginning of TLS; b) introduction of all factors affecting heat conduction before microscopic model *J.* a) House insulation can be motivating for students and an unifying thread for all the proposed activities; b) improve the understanding of macroscopic behaviour may allow for a better justification of the microscopic interpretation

Data about students' achievements have also been collected. Analysis of results after the implementation in a Greek context has been already reported (Hatzikraniotis et al., 2010); preliminary data from the Italian implementation with about 20 students show that, as far as the students' achievements about the addressed contents, the results of the post-test are significantly different from those of the pre-test. A complete quantitative analysis of students' learning outcomes after the implementation of the TLS in the Italian context and the comparison with the results obtained in the Greek context will be reported in a forthcoming paper.

DISCUSSION AND CONCLUSIONS

Taking into account the introduced adaptations, the original designers agreed that the transferred version of the TLS has kept certain essential features of the module in terms of the core elements, as for instance, the use of a guided inquiry approach, the POE strategy, the adoption of a combination of virtual and hands-on experiments and the ICT-enhanced visualizations of microscopic model of matter. The adaptation of the overall conceptual sequence and the introduction of more quantitative aspects, carried out to better fit the original TLS to the local curriculum, were considered to have not affected the core elements.

In the context of the above evidence, it seems plausible to infer that context similarities such as school settings and educational practice between the Greek and Italian educational systems have plausibly acted as “facilitators” in the transfer process. First of all, the centralization of both educational systems seem to have played a key role: in particular, the fact that thermal phenomena was a content present in the both national and compulsory curricula favoured the implementation of the original TLS in the Italian context in usual school time, not requiring any extra school involvement of students and of the teacher who actually implemented the activities. Moreover, the circumstance that in both systems, at lower Secondary School level, Physics is taught as single subject, has driven the choice of the teacher involved in the actual TLS implementation on the basis of the implicit requirement that this teacher should have had a strong content knowledge to correctly exploit some features of the TLS (e.g., visualizations of heat conduction at microscopic level) and to conduct effective laboratory experiments. Also the similarities between the Greek and Italian contexts at the level of pedagogical practices, namely the predominant transmissive teaching approach based on textbooks, the overall weak orientation towards authentic scientific inquiry and the scarce use of laboratory activities, seem to have plausibly helped the transfer process.

Actually, the host group did not need to strongly adapt the proposed activities to the conditions of Italian teaching practice, since the original TLS designers had already taken into account very similar boundary conditions. In a similar way, the school settings (the average number of students per class, the somewhat limited laboratory and ICT equipment), very similar between Greece and Italy, favoured actual school implementations which were highly consistent in the original and host contexts.

In concluding this paper we may note that we have qualitatively described and discussed the transfer of an effective TLS between two educational contexts, the Greek and Italian one, which share some key common characteristics as, e.g.: a centralized curriculum, a general lack of authentic inquiry laboratory practice in science teaching, a traditional teacher-centred pedagogical habit. Basically, the comparison between the original and adapted TLS, carried out in the framework of the ARI model, has shown that these common characteristics have plausible helped the transfer process. This implies that some commonalities in achievements and difficulties when implementing this TLS in these two countries may be expected.

However, similarities are not a sufficient condition for successful transfer, as it has emerged looking back at the whole process. We consider that designers’ shared science education research framework has also played an important role since common views about pedagogical strategies as guided inquiry, POE, modelling and ICT-based interventions, speeded up the process of de-contextualization and re-contextualization of the core elements of the original TLS. In the future, supplementary analysis of the overall transfer process, documented by means of different data sources, will provide additional insights to scholars interested in the more general problem of transferring effective practices across different European countries.

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PART 10: EVALUATION AND ASSESSMENT OF STUDENT LEARNING

Editor: Robin Millar

Development, validation and use of standardized tests, achievement tests, high stakes tests, and instruments for measuring attitudes, interests, beliefs, self-efficacy, science process skills, conceptual understandings, etc; authentic assessment, formative assessment, summative assessment; approaches to assessment.

This part corresponds to strand 10. It contains 13 papers.

TABLE OF CONTENTS OF PART 10
EVALUATION AND ASSESSMENT OF STUDENT LEARNING

TOWARDS THE DEVELOPMENT OF A MULTIMODAL, TASK-BASED APPROACH FOR INVESTIGATING CHILDREN'S IDEAS

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Abstract: The constructivist perspective maintains that children will have formed some representations of scientific phenomena in order to understand the world around them (Driver et al, 1994). Resulting 'alternative frameworks' are subject to change when children begin to learn science formally in school (Driver & Bell, 1986). This has led to a wide body of research aimed at identifying and understanding the underlying mechanisms that support conceptual change dynamics (Vosniadou, 2008). Contemporary literature typically accesses conceptual knowledge through verbal reports gained during individual interviews or activities (Primary Space Projects, 1990-1994). Whilst these approaches have been successful in helping to understand what children know and can do this bias towards language and linguistic capabilities at the expense of other forms of communication may prevent a comprehensive understanding of knowledge growth particularly if children are not able to clearly or fully articulate their ideas (Goldin-Meadows, 2000). This paper discusses the development of a new and innovative multimodal, task-based approach to investigating children's ideas in science. The approach utilises highly contextualised practical science activities in order to elicit and challenge existing ideas and incorporates a video analysis of non-verbal gestures and actions. It is suggested that this method provides a more holistic and robust approach for investigating children's ideas and concepts in science.

Keywords: Multimodal research, audio-video research, practical science activities, collaborative group work, verbal and non-verbal communication

INTRODUCTION

Constructivism remains one of the most influential contemporary approaches to understanding how children come to learn science in school classrooms. The constructivist perspective maintains the view that children will have formed some representations of many of the phenomena studied in school science based on their previous experiences and reflection on those experiences in order to understand the world around them (Driver, Asoko, Leach, Mortimer & Scott, 1994). These initial representations are proposed to take the form of 'alternative frameworks' because of the explanatory scope that they provide children with. These 'alternative frameworks' contain conceptual understanding that frequently contrasts with the scientific explanations of the same phenomena and therefore they are subject to change when children begin their formal science education (Driver & Easley, 1978; Driver & Bell, 1986). Research investigating learning from this perspective has led to the development of a number of explanatory models identifying underlying mechanisms that support such 'conceptual changes' (for example Vosniadou & Brewer, 1987; diSessa, 1988; Sharp & Kuerbis, 2006, summaries in Vosniadou 2008; Limon & Mason, 2002). These models range in their depth and scope with some placing a high emphasis on purely cognitive processes

(Rumelhart & Norman, 1978; Posner, Strike, Hewson & Gertzog, 1982) whilst others attribute a strong role to motivational and affective factors (Pintrich, Marx & Boyle, 1993, Dole & Sinatra, 1998). There are significant difficulties associated with the comparison of these models because often the research investigates different participant populations, different domains of scientific knowledge or measures different levels of mental representation. The methodological approaches used during data collection are also subject to criticism, notably because there is a bias towards language-based responses.

Contemporary literature typically approaches the assessment of conceptual knowledge through verbal reports that are accessed through interviews or task-based activities (Osborne & Freyberg, 1985; Primary Space Projects, 1990/1994). Whilst this approach has been successful for generating a wide body of understanding regarding the knowledge that children hold, the bias towards language and linguistic capabilities may prevent a comprehensive understanding of children's knowledge particularly if children are not able to clearly or fully articulate what they know (Goldin-Meadows, 2000). In order to overcome this potential bias, the work presented here investigates the development of scientific ideas and concepts from a multimodal perspective. The multimodal approach to understanding children's learning is a new and innovative research area but one developing rapidly. Initial findings from wider research adopting this approach have demonstrated that during the course of their learning children utilise a number of different expressive modes in order to acquire conceptual knowledge. These modes include verbal dialogue, written pieces, drawings and other expressive art forms and non-verbal communication such as gesture, eye gaze and body posture (Kress et al, 2001). Whilst Kress et al's research focused on how different modes of activity support children's acquisition of concepts in science other researchers (for example Goldin-Meadows, 2000) have investigated the role that non-verbal language such as gesture has in revealing children's existing conceptual knowledge. One early analysis conducted by Crowder and Newman (1993) investigated the gesture and speech of thirteen children who were learning the science concepts associated with seasonal change. The results revealed that some gestures were 'redundant', others served to enhance the ideas expressed through speech, and in some cases gestures served as carriers of scientific meaning that was not present in language. This led Crowder and Newman to conclude that "*as long as ideas outstrip scientific vocabulary, one can expect to see gestures used by elementary science students to carry unstated ideas"* (p.176). This previous research highlights an important role for other responses types such as non-verbal gesture that may be as important to consider particularly if assessments of children's knowledge and underlying learning processes are to be made.

In one summary paper that drew on a body of research investigating different areas of children's problem solving ability Goldin-Meadows et al (1993) suggest that further to revealing actual knowledge the non-verbal gestures of children and their language based response could, when compared with each other, reveal learning processes in action. This is suggested to occur because new ideas and concepts appear to be available to non-verbal communication before they become accessible through speech. Goldin-Meadows et al proposed that stability between speech and gesture characterises a stable understanding of a concept but a mismatch between the two responses types characterises the time in which children are moving between conceptual understandings and using more than one framework of understanding. It was argued that the "*gesture-speech mismatch signals to the social world that an individual is in a transitional knowledge state"* (Goldin-Meadows et al, 1993, p.279). Taken as a whole this research is suggestive that contemporary language based approaches may be insufficient for capturing the processes of conceptual change as they fail to take account of other response types that may be crucial for revealing conceptual knowledge. In order to overcome these problems the work presented in this paper discusses the development of a new and innovative multimodal, task-based approach to investigating children's ideas and concepts in science.

The work presented here discusses an initial analysis of findings from an ongoing doctoral level research project currently in the main data collection and early analysis phases.

RATIONALE

This project specifically investigated the following research questions:

- how and to what extent do multimodal analyses of children's verbal and non-verbal communication facilitate understanding of the science ideas and concepts that children have;
- to what extent can such analyses be utilised in order to explore and understand the dynamics that support conceptual change?

METHODS

This project here utilised a cross-sectional design by studying the scientific ideas and concepts of three groups of children aged seven, eleven and fourteen years in English Primary and Secondary schools. A total of 101 children took part in the study, the children were distributed as follows across the three age groups; 34 aged seven, 44 aged eleven and 15 aged fourteen, with an additional group of 8 Secondary School children (aged between twelve and fifteen) from a school science club. All of the children participating in the study completed two practical science activities, one in electricity and one in floating and sinking. The practical activities were designed to elicit children's ideas by probing understanding as they completed familiar tasks (for example, testing different materials to observe whether they float) whilst subsequent tasks were designed to challenge existing ideas (for example, pushing an inflated balloon into water in order to feel the upthrust force and observe the change in water level). These activities permitted analysis of both existing ideas and concepts and the opportunity to observe the outcome when concepts begin to change or are challenged.

The practical science activities took place in small groups (approximately five children of the same age in each group). The activities were highly contextualised to the concepts studied, interactive and dialogic in nature and included protocols from participant observation and interview based methodologies. Each practical science activity lasted approximately one hour. All were audio-video recorded in order to capture events fully and to obtain gesture in transmission.

In order to explore the potential role of each response type the transcription and the subsequent analysis focused on the modes and areas shown in figure 1.

Levels of Comparison
Between Activities
Between Age Groups
Between Participants
Between Individual Groups

Levels of Analysis
Analysis of Verbal Responses
Analysis of Drawing
Analysis of Written Responses
Analysis of Gesture and Non-verbal Responses
Analysis of Social Interaction
Analysis of the Activity

Figure 1: The different levels of comparison and analysis explored in the study.

Transcripts coded both verbal and non-verbal responses collected throughout each of the activities. Analyses of the data included both within and between age group comparisons for children's ideas and concepts related to each of the science topics. Verbal and non-verbal data were interpreted using a content analysis approach and analysed in order to capture matches and mismatches between the two forms of communication.

RESULTS

Although this project is still in the early stages of analyses the results are beginning to reveal important information about children's gestures. Our data demonstrates that children's gestures can have three different roles, they can be redundant to the speech, they can support the ideas discussed in speech and they can contain vital clues and cues to children's ideas that are not contained within the verbal responses. These findings are consistent with the previous research discussed above (Crowder & Newman, 1993). For example, the analyses investigating the gestures that the children used when discussing their ideas for electricity following the construction of a simple circuit came in three distinct forms. Some children used one hand to draw a path that began at the battery and followed the wire before stopping at the bulb. Other children used one hand to draw a path that began at the battery, followed the path of the wire to the bulb before continuing around the second wire and stopping at the battery. Finally, some children used both hands to draw a path that began at the battery, each hand then followed a different wire until they met at the bulb and stopped there. This final example is resonant of the 'clashing currents' model discussed in the research literature (Osborne et al, 1991). However, using the children's verbal responses in isolation would not have permitted the identification of these three distinct models. In all cases children's verbal responses contained the same or very similar information and they frequently stated that 'the electricity flows through the wires to the bulb'.

Our results also suggest that the gestures that children produce during our activities appear to fit into five different categories. These gestures contain both scientific and social information which can help us to gain a greater understanding of what children know and can do (Callinan & Sharp, 2011). Figure 2 below provides an overview of the types of gestures identified during the study.

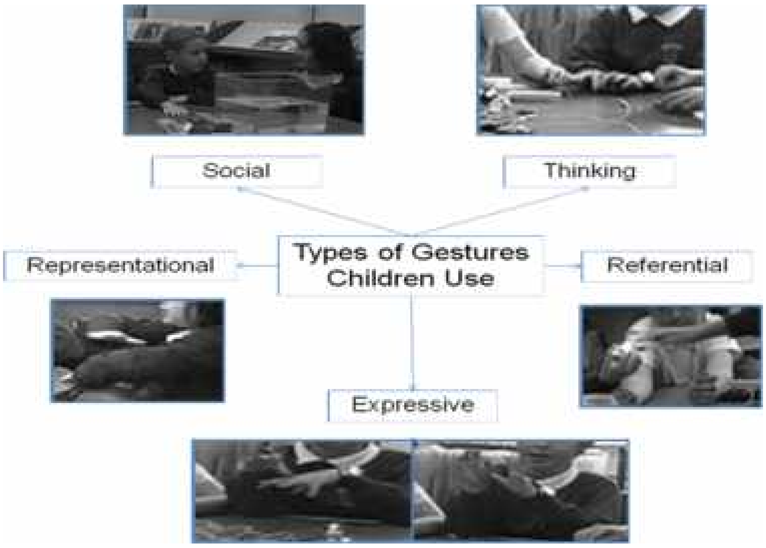

Figure 2: The types of gestures that children use when completing practical science activities and discussing their ideas (Callinan & Sharp, 2011).

Scientific gestures came in four main forms:

- referential – e.g. pointing to objects, pictures or people in the immediate environment;
- representational – e.g. re-enacting the behaviour of objects, the content of pictures, or factors related to people;
- expressive – e.g. often including repetitive movements or building on representational gestures revealing the values associated objects, pictures or people;
- thinking – e.g. finger drumming, waving hands, head holding or face and hair stroking.

The gestures previously discussed which children produced when probed for their understanding of electricity reflect an example of the representational gestures identified. The children used their hands to re-enact the behaviour of 'objects', in this particular example, that 'object' was the 'flow' of electricity within a circuit.

While scientific gestures appear to play a crucial role in facilitating our understanding of children's scientific ideas, social gestures also have an important role for facilitating our understanding of how young children use input from peers in order to structure their responses to probes of knowledge or to seek social support when they are experiencing uncertainty or difficulty in generating a response. During the course of this study there are many instances which demonstrate how children have used such non-verbal approaches to eliciting help from each other. Whilst these gestures can be interpreted as demonstrating little information regarding children's scientific understanding they are particularly helpful for revealing how children negotiate meaning in groups.

Further work will be undertaken to explore how this classification of gestures fit into previously identified categories, for example Kendon's continuum (McNeill, 1992) and Roth (2003).

The match – mismatch analyses of verbal and non-verbal communication further revealed that how non-verbal gestures can contain valuable information regarding ideas and concepts that are not included in verbal responses. For example, analyses of non-verbal gestures produced during the floating and sinking activity revealed that children might be considering variables such as the shape of objects even though such references were frequently omitted from verbal responses.

CONCLUSIONS

The preliminary results to the study support the hypothesis that the multimodal, task-based approach presented here offers a more comprehensive route for studying children's ideas and concepts of scientific phenomena. Notably the study produced evidence that revealed that non-verbal communication such as gesture can contain demonstrations of conceptual knowledge. In addition, a typology of gestures used by children when discussing their ideas for electricity and floating and sinking is proposed. These gestures range from those containing conceptual knowledge to gestures which reveal interpersonal non-verbal cues requesting social support from other children if difficulties are encountered. The comparative analysis suggests that using children's verbal responses in isolation are insufficient and can lead to biased interpretations of what children know and can do. The multimodal task-based approach proved particularly useful for investigating younger children's ideas particularly when they have difficulty in articulating what they know coherently or comprehensively.

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AN INVESTIGATION OF THE RELATIONSHIP BETWEEN PRE-SERVICE TEACHERS' REFLECTIVITY AND ACADEMIC PERFORMANCE

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Abstract: The aim of this study was to investigate pre-service teachers' reflectivity and to examine its relationship to their academic performance in a Chemistry Laboratory Course. The participants were 16 second-year pre-service teachers at the Science Education program in an education faculty in Turkey. A combination of qualitative and quantitative research approaches was used in the study. Data on the pre-service teachers' reflectivity was sourced from their learning logs and their academic performance was sourced from end-of-term examinations. In addition, interviews were also conducted with pre-service teachers to determine their views on the effects of keeping learning logs on their learning. According to the results, pre-service teachers exhibited very low levels of reflectivity based on Moon's (2009) classification of levels of reflectivity. There were no indications that reflectivity was related to the teachers' academic performance. However, the interviews conducted with the participants showed that learning logs had a positive effect on their learning, especially when feedback was given. Implications of the results are discussed and suggestions are provided.

Keywords: Reflection, level of reflection, academic performance, learning logs, chemistry laboratory

INTRODUCTION

Reflective thinking has recently become one of the most popular issues in teacher education. Reflection is based on progressivism, which is rooted in pragmatic philosophy. Dewey, who is the pioneer of this philosophy, considered reflection as a special form of problem solving, through careful ordering of ideas linking each with its predecessor to resolve an issue (Hatton & Smith, 2006).

Reflective learning approach encourages active and responsible learners. It gives learners an opportunity to make their own decisions and reflect about their experiences. Thus students become aware of their actions and learn through experience (Wilson & Wing Jan, 1993; Tok, 2008).

In traditional learning approaches, informative role of the teacher makes the students dependent on the teacher to correct their errors. Therefore, the students don't participate in the learning process as decision makers. But in the reflective learning approaches, students can set their own learning goals and they can take responsibility for their own learning (Wilson & Wing Jan, 1993; Unver, 2003).

Various strategies can be used to develop reflective thinking, these are: writing for learning, concept mapping, questioning, self-questioning, negotiated learning and self- assessment (Wilson & Wing Jan, 1993).

This study deals with writing for learning. The act of writing has a positive impact on students' learning. By writing, students understand how to adopt their prior knowledge with their new information and they think about what they know (Gunel, Kabataş Memiş &

Buyukkasap 2009). Studies on writing for learning find are widespread in international literature but in Turkey these are not yet put on the agenda (Gunel, Uzoğlu & Buyukkasap, 2009).

The students' writing can be analyzed in order to define the level of their reflection. For this purpose, Moon (2009) introduced four levels of reflective writing: descriptive writing, descriptive account with some reflection, reflective writing (1) and reflective writing (2).

It is seen that especially in international literature there are many studies dealing with reflection in its various aspects. Among these studies, the number of studies that determine the students' level of reflection (Wong & et all., 1995; Gipe & Richards, 1992; Chalk & Hardbattle, 2007; Sahin, 2009) or that investigate the relationship between the students' reflection level and their academic performance (Chalk & Hardbattle, 2007) are relatively low. Also the existing studies deal with different research areas and there are a lack of studies in pre-service teacher education in this subject. This study will contribute towards the body of knowledge in this area.

The aim of this study is to investigate if there is a relationship between pre-service teachers' level of reflection and their academic performance in a chemistry laboratory course through analyzing learning logs, achievement test scores and their perceptions of the effects of the process on their learning.

METHOD

The participants consisted of 16 second-year pre-service science teachers from a faculty of education in Turkey. All of the participants were enrolled in 'General Chemistry Laboratory III, which one of the researchers in this study taught. The class met once a week for a two-hour section. The data for the study were collected from participants' learning logs, end of term exam scores and semi-structured interviews.

Learning logs were used for defining participants' reflection levels. At the end of the first laboratory section, participants were informed about their assignment. This study uses two-column writing, which is one of the types of writing in a reflective environment. Participants were asked to write the information they learnt from the activity on the left side of a page and to record their personal reactions and reflections on the right side of a page. The left side of the assignment was called the 'summary' section and the right side of it was called the 'learning log' section. They were told that there was no limitation to the number of pages. They were also told that the assignment wasn't going to be evaluated officially and that it would only add to their own learning.

At this stage, 16 pre-service teachers volunteered to prepare the assignments. The participants were asked to prepare one learning log for every two weeks. When the first assignments were controlled, it was understood that the participants didn't understand what was asked of them. Some of them wrote the subtitles of the subject on the summary side and what they learnt on the learning log side. The real aim was restated to the participants as feedback for these papers and some guiding questions were added to the learning log section. These made the participants better understand what they were required to do. Therefore, these papers were not evaluated. Otherwise the first assignments, participants were asked to prepare 5 assignments. Most of the participants didn't complete the number of assignments. These participants were not forced to complete more assignments.

Each participant's learning log was examined and graded from 1 to 4 in accordance with the reflection levels determined by Moon (2009: 67-69):

"Descriptive writing: This account is descriptive and it contains little reflection… Ideas tend to be linked by the sequence of the account/story rather than by its meaning… Most points are of equal importance.

Descriptive writing with some reflection: This is a descriptive explanation that gives some reflection signals but does not actually show much reflection… It focuses on the event as if there is a big question or there are questions to be asked and answered… Asking the questions makes it more than a descriptive explanation, but the inefficiency in responding to the questions means that there is little actual analysis of the events.

Reflective writing (1): There is definition but there are reflective comments for some special focuses… The explanation contains some analysis and the importance of explaining motives or reasons for behavior is realized… There is some self-questioning and a also willingness to recognize the overall effect of the event on himself/herself.

Reflective writing (2): There is clear evidence of thought and internal dialogue when the event is reversed. The explanation contains deep reflection, and it incorporates an awareness that the frame of reference with which an event is viewed can change. A metacognitive stance is taken… It is observed that learning is realized from experience and points which are written for learning."

Two writers of the study was analyzed all participants' learning logs independently.

To examine the categories' reliability correlation coefficient was calculated between the two writers' rating. A correlation of 0.93 ($p<.01$) was found which indicates a strong, positive and statistically significant relationship. Since the writers' rating of participants' learning logs were close to each other it can be said that inter-rater reliability for the categories was high.

The reflection level of each participant was found by taking the mean average of all of his/her learning logs. An end of term exam was used as the determiner of the participants' academic performance. All of the exam papers were evaluated by using an answer key. According to the answer key, the maximum points that could be gained from this exam was 100 and the minimum was 0. A correlation coefficient was calculated in order to measure the degree and the direction of the relationship between the pre-service science teachers' academic performance and their reflection level.

Semi-structured interviews were carried out with 9 of the teachers to find out what effect the learning logs had on their learning. The interviews were conducted with participants who prepared 3 or more assignments and volunteered to conduct interviews. The data collected from the interviews underwent content analysis. Additionally we examined one of the participants as a case study which we thought that her statements give more information about the effectiveness of the reflection process.

A single unique identity number was generated for each participant. Names were not used. A nickname was given to just our case.

FINDINGS AND DISCUSSION

In this section of the study, data collected from the participants' learning logs, achievement tests and interviews are presented. This section is presented in three parts. In the first part, the reflection level of the pre-service teachers is determined and the relationship between their academic performance and reflection level are examined. In the second part of the study pre-service teachers' ideas about the reflection process is determined and in the third part one of the participant's responses is examined as a case related to the data obtained from the interviews.

The Relationship Between Academic Performance and Level of Reflection

The table below provides the data on the pre-service teachers' levels of reflection and the relationship between their levels of reflection and academic performance.

Table 1. The relationship between the pre-service teachers' levels of reflection and academic performance

Student	Reflection level							
ID	Assignment number							
	I	II	III	IV	V	Number of assignments	Sample mean	Exam mark
1	3	2	2	2		4	2.25	47
2	3	3	1			3	2.33	9
3	2	1		2	2	4	1.75	26
4	2	1	1	2		4	1.5	93
5	1	1	1			3	1	19
6	1	1	1			3	1	31
7	2	2	2			3	2	15
8	2	2		1	1	4	1.5	27
9	1	1	1	1	1	5	1	10
10	2	1				2	1.5	16
11	2	2	1			3	1.67	37
12	2	2	2	1	1	5	1.6	11
13	2	1	1			3	1.33	5
14	1	1	1			3	1	26
15	1	1	1	1		4	1	37
16	2	2	2			3	2	42
							Correlation	.07

In table 1, the numbers in the first column represent the study participants and the
Roman numerals represent five assignments completed by the participants. Each learning log of the participants' was graded from 1 to 4 in accordance with the reflection levels determined by Moon(2009)'s categories. Analyzing the table, it can be seen that no learning log earned 4 points and that 53 out of 56 writings that pre-service teachers produced fall under the category of "descriptive writing" or "descriptive writing with some reflection" as described by Moon (2009). Only three writings from two participants had some evidence of what Moon called reflective writing (1). In her study, Sahin (2009) also examined 20 pre-service science teachers' reflective thinking ability according to their weekly journals; similarly, she determined that their descriptive reflectional thinking ability was more dominant. She also pointed out that pre-service teachers' critical reflective thinking ability was less developed and that some of them totally lacked it.

Table 1 also represents the number of assignments prepared by each pre-service teacher and their average reflection levels and the exam scores. When the participants' exam scores and reflection levels are examined together, a correlation of .07 was found, indicating that there is no relationship between reflectivity and academic performance. In a similar study Chalk and Hardbattle (2007) carried out with 15 science and engineering students, they found a positive, weak correlation between the students' academic performance and their reflecting writing scores.

The reason that there is no connection between the pre-service teachers' reflective writing scores and academic performance could be that so many of the participants' reflection levels were so close to each other. Another reason could be that participants did not complete their all assignments. In this study, participants were expected to prepare 5 assignments but even though all of the participants volunteered to take part only two of them completed their assignments. Therefore, the need to examine the correlation between the reflection scores and the performance of the participants who prepared 4 or 5 papers was felt. The obtained data is given in Table 4.

Table 4. The correlation between academic performance and the level of reflection

ID	Number of assignments	Exam mark	Reflection level
1	4	47	2.25
3	4	26	1.75
4	4	93	1.5
8	4	27	1.5
15	4	37	1
9	5	10	1
12	5	11	1.6
		Correlation: .2	

In this situation a weak correlation of .2 was found between the reflection scores and participants' academic performance. The correlation was not significant but the increase in the correlation supported our thinking that if the participants had completed all their assignments the results could have been different.

Pre-Service Teachers' Ideas About The Reflection Process

Semi-structured interviews were conducted with 9 of the participants to learn their views about the effect of learning logs on their learning. Analyzing the data from the interviews, pre-service teachers opinions were put into three categories.

Table 2. Pre-service teachers' views on the effects of learning logs on their learning

The effect of learning log on learning	f	ID	Number of assignments
Learning logs are effective on learning the subject when teacher gives feedback.	5	3	4
		6	3
		5	3
		4	4
		8	5
Learning logs are effective on learning the subject.	1	12	5
Learning logs are not effective on learning the subject.	3	2	3
		14	3
		1	4

In the first column of table 2, teachers opinions are presented and in the second column of the table the number of participants who attended in each category are presented. Three out of nine participants stated that preparing learning logs was rather entertaining for them and helped them to relax but they also noted that it had no effect on their learning. The other 6 participants stated that learning logs were effective for their learning. However, when the table is examined, it can be seen that these participants are separated into two groups. Five of them stated that without feedbacks the logs are not effective on their learning. Only one participant stated that learning logs are effective on learning whether there is feedback or not.

8 out of 9 participants who took part in the study couldn't see a direct connection between learning and preparing learning logs. One reason for this can be that the participants had come across such an application for the first time. The aim of learning logs is to develop students' metacognitive strategies (Ozsoy, 2008). However; metacognitive learning strategies (planning, controlling, managing) have no direct effect on the operating process (Tascı et al,

2008). Namely, participants' academic performance is expected to improve as a result of using skills such as planning, controlling and managing learning which are expected to develop as a result of reflective applications. Within this scope, it can be said that it is natural for the participants who have come across such an application for the first time could not benefit from the application or not be able to realize or express this indirect effect.

Also only 2 out of 9 participants prepared 5 learning logs. The other participants prepared fewer assignments. The participant who believes that preparing learning logs is effective on learning is one of the participants who prepared the most logs (5 logs). When the time of the application is extended, the pre-service teachers can better analyze the effect of preparing learning logs on themselves.

Case Study

Elif. This part of the study examines Elif (ID 12) as a case study. Elif is one of the participants of the study who completed all of the assignments and the only participant who found preparing learning logs effective on learning whether there is feedback or not. We thought that her statements give some insights about the effectiveness of the reflection process. The following quotation shows that she really understood what a learning log is:

> *"I can establish a relationship between the level of learning and the right side of the paper. I mean, at the evaluation stage the student already knows what she has learnt, what she can and can't do; in short she can see herself like the reflection of a mirror… The student can exactly see himself/herself and this vision directly affects his/her learning".*

Even if Elif's learning logs did not enhance her success at the end of term exam results, the data obtained from the interview carried out with her showed that they contributed to Elif taking responsibility for her learning and also gives some information about the process of keeping learning logs.

Elif explained that she accepted to attend the implementation because she found the General Chemistry Laboratory III course content difficult and she did not know how to study it and thought that it may be a solution for her to pass the course. But she said that, firstly she couldn't understand what the instructor asked them to do that is why this was the first time that they asked to keep a log for a course. And she added that even though she was a volunteer, she did not pay much attention to her first assignments and did not study the course. Then she continued that the assignment feedback helped her to understand how to do it and also directed her to study more:

> *"At the beginning I used to say that I can't do it and put it aside and the reasons were that I didn't attend the lesson and I didn't have any preparation for it too… The more you write me (give me feedback) I started to ask myself why do I not study… I mean this made me study better…"*

She also stated that she started to prepare learning logs for other courses. With formative evaluation the students' special problems in their studies are dealt with and feedback is an important part of it. Even if it is beneficial for all students, it is especially effective for students whose level of success is low (Black and William, 1998). In this case Elif may have gained awareness about her learning responsibility because of a teacher who gave feedback to her.

CONCLUSIONS AND RECOMMENDATIONS

The study aimed to determine whether there is a connection between reflection levels of pre-service teachers and their academic success. At the end of the study it was seen that none of the reflection levels of the pre-service teachers went beyond description; namely, they couldn't reach the level of reflection. Therefore; the application couldn't create a difference in the academic success of the participants which was determined with an exam. However; even though it wasn't effective on their exam results, the interviews conducted with the participants showed that learning logs had a positive effect on their learning, especially when feedback was given.

The fact that the pre-service teachers' reflection levels did not go beyond description in this study shows that pre-service teachers who come across the notion of the reflection for the first time need a longer period of time to develop this ability. If the pre-service teachers had reached the level of reflection the effect on their academic success could have been seen more clearly.

As a result, this study is important because it provides data about the reflection level of pre-service teachers. However, it is a small scale study and lasted only for a semester, and this may not be long enough for significant changes to take place. Improving pre-service teachers' reflective skills may require longer periods of time. Therefore, further studies could consider training pre-service teachers to develop their reflective skills over a longer period of time and possibly use longitudinal studies to monitor its effects on learning. In addition, as it is the case for all social studies that use human beings as the sample, participants' unique characteristics and physical and other conditions may always affect the results. Thus, there is a need for replicating the study with a different sample to verify the results and specify further effects.

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USING LARGE SCALE TEST RESULTS FOR PEDAGOGICAL PURPOSES

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Abstract: The use and influence of large scale tests (LST), both national and international, has increased dramatically within the last decade. This process has revealed a tension between the legitimate need for information about the performance of the educational system and teachers to inform policy, and the teachers' and students' use of this information for pedagogical purposes in the classroom. We know well how the policy makers interpret and use the outcomes of such tests, but we know less about how teachers make use of LSTs to inform their pedagogical practice. An important question is whether there is a contradiction between the political system's use of LST and teachers' (possible) pedagogical use of LST. And if yes: What is a contradiction based on? This presentation will give some results from a systematic review on how tests have influenced the pedagogical practice. The research revealed many of the fatal wash back effects known from other research but gave additionally some insight in teachers' attitudes towards LSTs. To account for these findings results from another research project - the Validation of PISA – will be included. This project analyzed how PISA has influenced the Danish educational system and the different theoretical foundations of PISA and most teachers' pedagogically oriented, formative assessment, thus explaining the teacher resentment towards LSTs. Finally, some principles for linking LSTs to teachers' pedagogical practice will be presented.

Keywords: Large Scale Test, formative, assessment, pedagogic, PISA

BACKGROUND AND AIM

Testing of pupils' knowledge and skills in schools has been common practice in many school systems for a long time. However, the format and the purpose of this testing has shifted across time and across systems as it has increased in its scope and extent. An overall explanation for this growing interest in large-scale tests may be found in the increased globalization and marketization of the educational system forcing policymakers to find tools for gathering information about their own system's performance. This is given precise expression in the statement from PISA (OECD, 2004) that:

Across the world, policymakers use PISA findings to:

- *gauge the literary skills of students in their own country in comparison with those of the other participating countries*
- *establish benchmarks for educational improvement …*
- *understand the relative strengths and weaknesses of their educational system.*

However, there is enormous variation in how assessment is conceptualized and operationalized in different educational systems and even within the same system. Even though the primary purpose of mandated testing in most educational systems ostensibly serves the function of increasing the quality of teaching there are different emphases. As such this is a reflection of the different weighting of specific goals. For instance whilst some systems emphasize the purpose of monitoring the system using tests based on representative samples of students in selected grades and in selected subjects (e.g., Finland and New Zealand), other systems highlight the use of tests for accountability purposes requiring that all students are tested for the purpose of reporting indicators of performance at the sub-system and school level (eg. UK and Ireland). Other systems, however, develop tests mainly to be used by the teachers as tools for monitoring and improving their own practice (e.g., Sweden and Denmark).

This widespread use of system wide testing of students testifies that policy makers across the world hold a common belief that tests are important agents of change leading to improved quality of schools. But it is crucial to underline that the increase in LST is not due to pedagogical reasons and are not based on teacher formulated needs in classroom contexts, but an overall (and legitimate) political wish for increasing the quality of the educational system. The question is whether there is a contradiction between the political system's use of LST and teachers' pedagogical use of LST. And if yes: Is it possible to harmonize or integrate these two applications of LSTs so they can serve the interests of both policymakers and teachers? However, although we know well how the policy makers interpret and use the outcomes of such international tests, we know less about how teachers make use of large scale tests to inform their pedagogical practice. One first step, then, is to establish what use teachers are currently making of such assessments. A Danish study systematically reviewed all accessible research on how tests influence teachers' pedagogical practice (Nordenbo, S. E., Allerup, P., Andersen, H. L., Dolin, J., Korp, H., Larsen, M. S., Olsen, R.V., Svendsen, M.M., Tiftikci, N., Wendt, R.E. & Østergaard, S., 2009). The method and the main results from this study will be presented below. The results will subsequently be interpreted from two different perspectives. One will explore the political implications of large scale tests in an understanding of teachers' dislike of such tests (Dolin & Krogh, 2010). The second will analyze the different theoretical foundations of large scale tests and most teachers' student assessment (Gipps, 1999; Krogh & Dolin, 2011; Buhagiar, 2007;).

METHOD: A SYSTEMATIC REVIEW OF THE LITERATURE

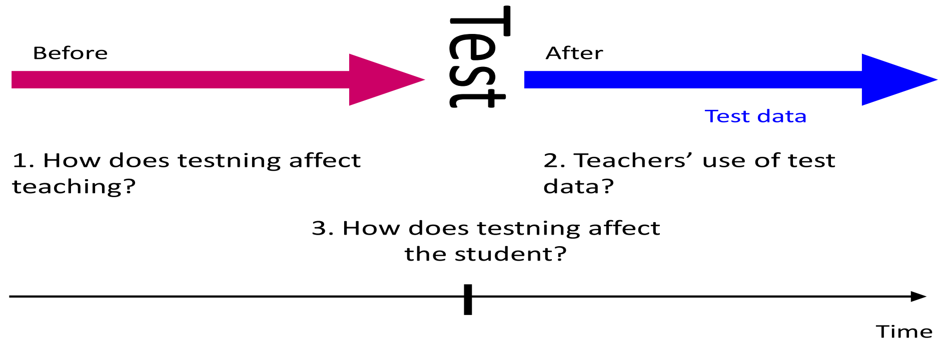
Motivated by newly introduced national tests, the Danish Clearinghouse for Educational Research initiated in 2007 a systematic review (a meta study) of the two questions:

How are tests used for pedagogical purposes by teachers? and

What are their effects on the pedagogical practice?

The author participated (together with three other Nordic researchers and the Clearinghouse staff (including librarians, research assistants etc.) in this review (Nordenbo et al, 2009). It was based on all published research in the period 1980-2008 of how tests had been used to improve the learning process.

A model of the pedagogical process which formed the basis of the review is shown in Figure 1. This article only includes question 1 and 2 from the model.



Figur 1. The research model

The research group narrowed the research questions in an ongoing process to keep the research literature on a manageable level and the final research questions were:

How can primary school teachers' individual and class oriented use of test data enhance teachers' didactical and/or subject specific teaching in classes without special needs students? (Question 2 in Fig. 1).

How does the introducing of tests affect the teachers' didactical decisions (question 1 in Fig. 1) and the students' learning approach (question 3 in Fig. 1).?

The questions only pertain to test types that form part of national tests in the Nordic countries.

Many studies, for instance those relating to documenting effects of introducing tests at a system level, where excluded from the review thanks to this narrowing of the research question, and 5986 references from the first search were cut down to 118 documents of which some, after a more thorough reading, did not fit the criteria. The remaining 61 publications were re-described according to the EPPI Centre data extraction and coding tool for education studies v2.0 (EPPI Centre, 2002). This tool lists 87 categories to describe a research project, covering the project's purpose, context, design, method, results, and research and report quality. For each study these categories were filled in the very fixed template, which makes it possible to extract the research evidence for each category. The tool can be criticised for its relatively rigid approach to research (Bennett et al, 2005) but it gives a systematic overview of the research within a specific area. Based on the tool's quality criteria some publications were excluded and we ended up with a narrative synthesis based on 43 research projects.

RESULTS

Of the 43 studies that met the criteria for inclusion, only 6 studies related explicitly to science (Bauer, Mathison, Merriam, & Toms, 1990; Center for the Study of Testing, 1992; Danmarks Evalueringsinstitut, 2002; Smith, Hounshell, Copolo, & Wilkerson, 1992; Stone & Lane, 2003; Sturman, 2003). Some general characteristics of these studies: five of them were in English, four of which related to state accountability programs in the US, and one paper related to national assessments in England. All of these studies were based on teachers' retrospective self-reporting or perceptions on how one or several tests have affected their teaching. None of the studies in the review (including those from other subjects) addressed the whole chain from testing to improved learning. Given the significance of assessment on pedagogy and curriculum (Au, 2007), perhaps the most interesting, and for us who were involved, surprising result was that the international community of educational researchers seems to be disinterested in this topic, and most of the research identified as relevant to the overall research question posed by the study was classified as being of weak or moderate quality. As the science studies do not differentiate from the total sample, the following results are based on all studies.

The review revealed most evidence on question 1 in Fig. 1, about how the tests as such (i.e. the fact that testing is taking place) affect the teachers' didactical decisions. We concluded, in accordance with the general understanding amongst educational researchers, that:

- tests do affect the teacher's instruction in the intended way, but
- the effects are not uniquely positive, as

The review reveals considerable negative effects of introducing centrally administrated tests:

- a narrowed down or distorted realised curriculum: professional lines of thought are simplified, facts and mechanical skills are emphasized on behalf of creative and aesthetic perspectives
- teaching time allocated to test issues on behalf of not test issues
- teaching becomes addicted to teaching to the test and rote learning

As regards the question of the teachers' pedagogical use of test data (question 2 in Fig. 1) we first realized that none of the studies dealt with the teacher's interpretation of the information embedded in test data. So we really don't know whether teachers understand test results in accordance with the test developers' intentions. One finding to emerge, however, was that the teachers' sense of ownership of the tests seemed to play a central role in 'successful' systems. Teachers prefer tests adapted to the actual class and teachers prefer tests with multifaceted results - but these relations are vaguely investigated in the research literature. One study showed, that the very fact that a test is taken, can completely overshadow the teacher's openness for a pedagogical use of test data.

DISCUSSION

The interesting questions arising from these results are why LSTs are so relatively badly received by teachers and difficult to use pedagogically - and whether they can be designed and used better for this purpose?

One group of answers relates to the way LSTs are introduced and used politically. Teachers often lack sense of ownership to LSTs and as our research showed, this is one of the main factors contributing to teacher acknowledging the relevance of a test and hence opening for a pedagogical use of tests. The tests are designed by others and not suited the teachers' own classroom (for which they compensate by fitting their teaching to the test!). At that, the results of these tests are often used against teachers: Students perform badly equals teachers do a lousy job! This is in many ways an interesting reaction from the political/educational system, a reaction you would seldom experience in other areas of public life. Could you for instance imagine soldiers returning from a lost battle being met with critical comments?
At the same time, test results often have political implication that will affect the working conditions for the teachers. The research project 'Validation of PISA in a Danish context' (http://www.ind.ku.dk/english/projects/) analysed the relevance and consequences of PISA science in a Danish context. The project points out the fact that the PISA2003 results were released Dec 4th 2004 and the Danish government introduced obligatory tests on most levels

Dec 7th 2004. (Dolin & Krogh, 2010). Danish/literacy, mathematics, and all science subjects are now tested, and most tests are placed around the 15-year-old age window. The Danish Teachers' Union tried, unsuccessfully, to rebut the test initiative with results from a survey showing that Danish teachers were already testing in their classes.

Coinciding with such direct implications, LSTs often provide results on a very high level of aggregation, which are used to change a whole system, and hence introducing changes, that neglect facts on lower levels. The PISA2000 report, for example, indicated that larger schools provide for better student performance than smaller schools. These results have impacted the Danish debate where the PISA chief researcher as late as 2007 stated that larger schools (at least 700-800 students) produce better student performance and improve economy (Hvid & Johansen, 2007). Local politicians have been happy to see economical and quality aims coincide, and the conclusion has been used to close a number of smaller and presumably more expensive schools (Brøndum & Fliess, 2007; Hvid & Johansen, 2007) – irrespective of the performance of the specific school. Surprisingly, however, comments in the Danish PISA 2006 report questioned the validity of this conclusion: "PISA 2000 indicated that students in larger schools have better science skills, also when these [were] corrected for relevant background factors, but … this tendency is not statistically significant in PISA 2006" (Egelund, 2007, p. 200).
So, LSTs often influence the general terms as well as the everyday working conditions for teachers in a negative way, for which reason teachers often meet them with opposition.

A more profound reason for teacher opposition to LSTs is the different values inherent in the deeper logic of LSTs and teacher assessment, respectively. Any LST test must be reliable and they are therefore forced to compare relatively simple aspects of student performance, while the (valid) test of advanced competencies are complicated and expensive. Teachers in their daily practice struggle with teaching their student these complex competences so they often find the simplicity of LSTs inappropriate for assessing the results of their teaching. This was reflected in the results from Nordenbo et al (2009) showing that teachers prefer tests with multifaceted results.
Even more profound is the different theoretical foundations of LSTs and most teachers' student assessment. The 'Validation of PISA in a Danish context' – project establishes two different paradigms for assessing students (Krogh & Dolin, 2011), based on different understandings of knowledge and learning. PISA, like all LSTs, sees student abilities as constant across different assessment situations and in this respect is based on a post-positivistic learning understanding. Much teaching, on the other hand, is based on a socio-cultural approach, seeing student abilities as dependent of/linked to the assessment situation (Gipps, 1999). The post-positivistic, psychometric oriented test design, standardized and with high reliability, that characterizes LSTs, is in contrast to most teachers' socio-cultural, hermeneutic oriented assessments, classroom adaptable and with high validity.
Seen in this light, it is not surprising that many teachers have difficulties in using LSTs for pedagogical purposes and even often have hostile feelings against them.

PERSPECTIVES

The more aligned LSTs can be with class room practice, the more likely it is that they can be used for pedagogical purposes. Such an alignment can in principle consist in LSTs being adapted to classroom practice or teacher assessments being transformed into LST results. On the face of it, it seems more accommodating to try to transform formative and teacher summative assessment procedures into LST results.

What is needed, then, is an assessment system, that can give summative results on student level, that can be aggregated to higher levels - for political purposes - and that can be used by teachers for formative purposes.
These systems have not yet been designed in full scale. But many approaches seem possible. You could for instance extract evidence of student performance form classroom works produced during the course (eg. electronic portfolios). This could be done using computer based technologies where substantial research is done to enhance the possibilities for assessing complex competencies. In general, when students are learning online, there are multiple opportunities for gathering data in the course of learning that can be used for assessment.
The possibilities for integrating LSTs and classroom based assessments exist by now. What is needed is research in usable procedures and policy makers daring implement them.

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ASSESSING EXPERIMENTAL PROCEDURES THROUGH DIFFERENT FORMATS – A COMPARATIVE STUDY

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Abstract: Assessing is, next to instruction, one of the two faces of any education-medal. When it comes to assessing achievements in experimentation, there is a lack of instruments that focus on the process-aspects of experimentation. This focus has become compulsory with the advent of most educational standards which emphasise the methodological character of experimentation as opposed to the output generated by it. This study aimed at suggesting and evaluating performance measures that derive from a shared process model of experimentation that is rooted in the SDDS-model and describes experimentation as a basic sequence of three steps: finding an idea or hypothesis – conducting an experiment – concluding from evidence. In the study, students were videotaped while working on three science experiments. They documented their progress in a novel report form and completed three MC-tests related to the scientific themes of the experiments. Performance measures were generated from video and report analyses. The measures from the report format as well as from the MC-tests were investigated with regard to their statistical correlation to the measure from video analysis, which served as a benchmark. Strong positive correlations (r>.65) were considered an indication of suitability as a performance measure. Results show that the report form can capture students' performance adequately provided they have had the time to familiarise themselves with the format. Concerning the suitability of the MC-test, this study cannot draw final conclusions as data were problematic. Preliminary findings suggest that increased efforts in improving the MC-tests might prove fruitful in identifying yet another assessment format for experimentation.

Keywords: experimentation, performance assessment, secondary school, science lessons

RATIONALE

Scientific experimentation probably is one of the most characteristic features of science classes in schools. This can be regarded a logical consequence of experimentation being a core feature of science *per se*. Experimentation is one of science's means to generate new knowledge by 'directing questions at nature and reading its answers from observations' (cf. Planck, 1942). Therefore, it has been prominent in science education since the 19th century (cf. Lunetta, 1998) – but unlike its role in proper science, in science classes experimentation has often not been an addressing of questions at nature. It used to be practiced in a format resembling some kind of chemical "I spy", in which someone (i.e. the teacher) knew the answer and the very method that students were meant to employ in uncovering their 'new' chemistry knowledge. Although this practice has been criticized quite early (cf. Baxter et al., 1992; Dewey, 1910; Lunetta, 1998), it was not before the advent of science education standards, that focus on aspects of scientific inquiry (e.g., NRC, 1996), that this has changed. Experimentation has increasingly been implemented in science classes to advance students' abilities in acquiring and constructing knowledge from experimental evidence. Yet, teachers are still ill equipped with regard to test instruments that help them to assess students' performance in experimentation. The proposed study aims to fill this gap and to provide teachers with a valid tool for performance assessment.

THEORETICAL BACKGROUND

Having to assess students' abilities in inquiry oriented experimentation means to transcend criteria that focus on the correctness of experimental results and to concentrate on the experimental procedure. There have been numerous suggestions how experimentation might be structured (cf. Emden, 2011) but ultimately they can all be brought to match with the basic three steps that are suggested in the SDDS-model (***S**cientific **D**iscovery as **D**ual **S**earch*: Klahr, 2000). This model from instructional psychology suggests that any researcher who encounters a scientific problem, first, needs to find an hypothesis in order to solve the problem. This can happen either by searching a mental representation of all the hypotheses that the researcher can draw from his prior knowledge or might even be triggered by surprising experimental evidence (cf. Klahr, 2000). After this, the researcher will search another mental space (experiment space) for adequate experiments that can be employed in order to solve the problem. Conducting the experiment and observing the results, he then can evaluate experimental evidence and come to a conclusion that will determine his subsequent actions. The SDDS-approach has frequently been taken up by science education researchers and translated into sequences fit for science classes (e.g., Hamann, 2004; Schreiber, Theyßen, & Schecker, 2009). One of these sequences – the NAW-approach (***N**aturwissenschaftliche **A**rbeitsweisen* (The Scientific Modi Operandi): Klos et al., 2008) – suggests to structure the experimentation process thus: (1) Finding an idea/hypothesis – (2) Planning and conducting an experiment – (3) Drawing conclusions from experimental evidence.

This structure is not wholly academic though and has found its way in some form or the other into science curricula throughout the world (cf. Emden, 2011). If, however, the process of experimentation is meant to be a learning goal of science education, there is the need to identify if the goal has been achieved in a performance assessment. Research in the area of experimentation tests and performance assessment reached a climax in the 1990's (e.g., Baxter & Shavelson, 1994). Typically, in these studies students would be confronted with experimentation materials to solve a given task. Procedures to solve the tasks could be narrowly guided emphasising the obtained results (e.g., Kruglak, 1951) or they could be more open highlighting the process of knowledge generation (e.g., Schreiber et al., 2009).

In attempts of convergent validation, performance measures that usually were generated from secondary products of experimentation (i.e. reports) were correlated with measures from paper-pencil-tests. The tests frequently did not operationalise what was understood by 'experimentation' in the same fashion as the performance assessment did (e.g., Comber & Keeves, 1973) or validation of the performance tasks was left out altogether (e.g., Harmon et al., 1997). In studies, that pre-date the era of skill-based teaching, instruments often did not concentrate on methodological approaches to experimentation but regarded technical issues instead (e.g., Tamir & Doran, 1992). If correlations between experimental and alternative measures were reported, the values favoured more open alternative measures (i.e. reports and open-ended questions) against close-ended Multiple-Choice-items (e.g., Baxter et al., 1992; Baxter & Shavelson, 1994). For close-ended instruments the observed correlations tended to not exceed r>.50; as far as open-ended instruments are concerned, lab-report based instruments appear to be best suited for capturing performance as compared to direct observation (cf. Shavelson et al., 1999). There appears to be no study that administers an MC-test which explicitly focuses on a general structure of the experimentation process as suggested above. This might be one reason for the apparent disadvantage of close-ended paper-pencil-instruments.

It follows that there is a lack of empirically validated test instruments that capture students' performance in experimentation in a process-oriented way. Hofstein (2004) suggests to use 'hot reports', i.e. to have students document their experimentation processes while they are happening and not *ex post facto* after finishing the experiment. Translating his experiences to a younger clientele needs to reduce the degree of openness that might be suitable for science students at university but will most likely damage workability at secondary school level (cf. Sweller et al., 2007). Therefore, a report format has been introduced in this study that provides separate entry slots for the three steps of experimentation (find idea-conduct experiment-draw conclusion). In addition, students are reminded at intervals to document their process in the form.

Regarding the administration of an MC-instrument, experience is drawn from studies with a test format which addresses process aspects of experimentation (NAW-test: Klos et al., 2008). Students are introduced to a pair of students who encounter a scientific phenomenon which they want to investigate. Potential ideas, experimental realisations and conclusions are provided and students need to choose between the options (multiple select, forced choice) regarding their correctness in the given situation.

RESEARCH QUESTIONS AND HYPOTHESIS

The suitability of both, the closed-format MC-test and the open-ended report format, was tested in an experimental study by means of convergent validation against performance results from videotaped experimentation phases. The study addressed these two research questions that share one research hypothesis:

Research Question 1: Does an open-ended report form modeled on SDDS measure student performance in experimentation validly?

Research Question 2: Does a closed Multiple-Choice-instrument modeled on SDDS (i.e., NAW-test) measure student performance in experimentation validly?

Research Hypothesis: The surrogate performance measures from the open-ended report form, the closed MC-test, respectively, correlate with $r \geq .65$ with a benchmark measure generated from video analysis.

DESIGN AND METHODS

Aim of the study was to validate two competing measures of performance in experimentation. Therefore, 339 students (M_{Age}=11.51 years, 53.4% male) from academic track and comprehensive secondary schools worked in pairs on hands-on experiments for 20 minutes, which they documented in an open-ended report-form (CR: distinguishing hard from soft water; OF: lowering surface tension of water to free oil from a flask; SS: distinguishing salt from fresh water). In addition, each of the students filled in the multiple choice NAW-test individually, which was thematically coordinated with the experiment. This was done because it is known that the theme of an experimental task has an effect on student performance (e.g., Brown & Moore, 1994), which would arguably be true for paper-and-pencil-based formats.

Students completed three combinations of hands-on experiment, report form and NAW-test in three separate test instances. This procedure takes into account that performance is not stable between several test instances in experimentation assessments (cf. Cronbach et al., 1997; Shavelson et al., 1999). In order to control for potential sequence effects the three

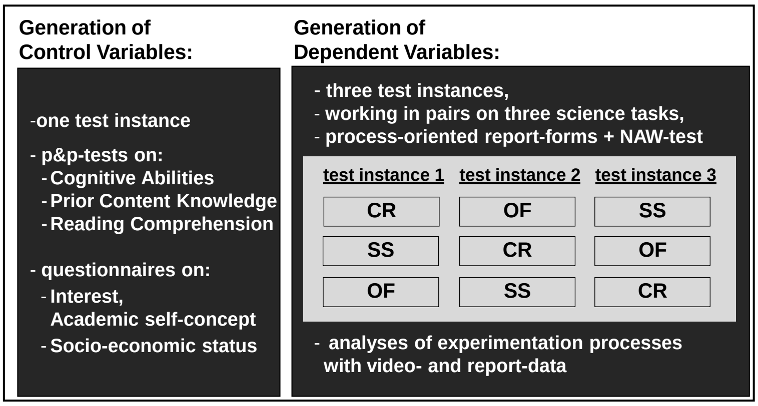

Figure 1 – Study Design

combinations were partially rotated through a Latin square (see Fig. 1). Students were assigned to the experimental conditions on basis of pre-test data from tests on cognitive abilities (Heller & Perleth, 2000) and reading comprehension (Lenhard & Schneider, 2006).

A subsample of students (n_{videos}=98) was videotaped during their experiments. This subsample was distributed evenly between themes of the experiments (CR, OF, SS). The resulting videos were analysed by trained coders focussing on students' demonstration of experimental procedures (cf. Walpuski & Sumfleth, 2009). On basis of the coders' results performance scores were calculated that took into account the directness of the experimental procedure as well as its methodological coherence (cf. Emden & Sumfleth, accepted), i.e. students who went through only one sequence of perfectly aligned instances of finding idea – conducting experiment – concluding outperformed students who needed to go through multiple and/or ill adjusted experimentation sequences (minimum score: 0, maximum score: 10). Correctness of the attained solution was scored in a latter instance and was not included in the process scores. In an analogous fashion, reports were analysed by trained coders and performance scores were determined. The paper-pencil-tests were scored summatively according to students' responses on the forced-choice items. Strictly speaking, only methodological coherence of the experimental procedures could be taken into account as multiple approaches to the experiment were not simulated in the paper-pencil-test.

RESULTS AND DISCUSSION

Reviewing the performance scores of students when working on the experiments from video analysis reveals that, although experiments are relatively difficult for the age group, the method of analysis promises a differentiation between shades of proficiency (s. 'range' in table 1). At the same time, the comparatively low average scores suggest that experiments could be improved to meet the abilities of the age group better, e.g. by reducing the amount of experimentation materials or offering additional aids. This impression can be confirmed in analogous analyses of the report sheets (Emden, 2011).

Table 1 – Performance scores and difficulties for experiments from video analysis

Theme			***M***	**range**	***SD***	**average diffculty ($\bar{P}$)**
CR	total sample	N=32	2.19	0.00–7.50	1.86	.22
	academic track secondary school	n=16	2.14	0.00–7.50	1.78	.21
	comprehensive secondary school	n=16	2.24	0.00–6.25	1.99	.22
OF	total sample	N=30	4.14	0.00–10.00	2.70	.41
	academic track secondary school	n=14	4.73	0.00–10.00	2.99	.47
	comprehensive secondary school	n=16	3.63	1.00–10.00	2.39	.36
SS	total sample	N=36	3.16	0.00–10.00	2.42	.32
	academic track secondary school	n=18	3.26	0.00–10.00	2.50	.33
	comprehensive secondary school	n=18	3.05	.17–10.00	2.39	.31

Analysing the performance scores from video and report-sheet analyses by means of investigating statistical correlation yields the Spearman's Rho coefficients (r_S) detailed in table 2. As can be seen, coefficients for the total sample do not meet the criterion anticipated in the research hypothesis. Yet, when school type is factored in, it becomes evident that the report format is of differing adequacy for students from both school types. While there is evidence in the case of the CR- and OF-experiments (hard/soft water, surface tension) that the report captures the same performance as gained through video analyses at academic track schools (r_S>>.65, p<.01), this is not true for the SS-experiment (salt/fresh water). For comprehensive schools the adequacy of the report format seems to be even reversed, indicating tentative suitability of the report only in the SS-experiment (.50<r<.65, p<.01).

Table 2 – Rank correlations between performance measures from video and report-sheet analyses

		total sample			academic track school			comprehensive school		
		CR	OF	SS	CR	OF	SS	CR	OF	SS
video/report	r_S	.492**	.521**	.383**	.801**	.861**	.294	.348	.300	.510**
	p	.000	.000	.001	.000	.000	.097	.060	.076	.001
	n	60	60	69	30	24	33	30	36	36

The suspicion that the academic track students' higher cognitive abilities bias the observable correlations could not be confirmed in partial correlation analyses (Emden, 2011). Therefore, additional analyses were run that distinguished between the instances in which performance data were collected. The results of these analyses are displayed in table 3; differences in sample size can be explained by exclusion of students from detailed analyses when irregularities in the order of the experiments' administration occurred.

Table 3 – Rank correlations between measures from video and report analyses differentiated by test instance

			test instance 1	test instance 2	test instance 3
academic track secondary school	CR video/report	r_S	.442	.900**	.806
		p	.234	.000	.053
		n	9	10	6
	OF video/report	r_S	1.000**	1.000**	.789**
		p	.	.	.002
		n	4	5	12
	SS video/report	r_S	1.000**	.783**	.293
		p	.	.004	.356
		n	6	11	12
comprehensive secondary school	CR video/report	r_S	.224	.028	.825**
		p	.562	.943	.006
		n	9	9	9
	CR video/report	r_S	-.357	.225	.866*
		p	.192	.532	.026
		n	15	10	6
	SS video/report	r_S	.649*	-.597	.944***
		p	.047	.068	.000
		n	10	10	11

Taking into account that a reduction in sample sizes affects the observable level of significance and compensating this by including $r_S \leq .10$ into the discussion, two tendencies can be seen in table 3: (1) For the CR- and OF-experiments there is a movement to stable and strong correlations over time; (2) for the SS-experiment, at academic track schools the correlations decline over time while at comprehensive schools there is irregular development.

The stabilizing movement might be explained by reference to Cognitive Load Theory (cf. Sweller, 2010) and the imposition of extraneous load. Since both the survey methods (open experiment and process oriented report) were novel to the students, it can be argued that operating both the methods imposes an increased extraneous load at the beginning. Only over time, by familiarisation, it becomes possible for the students to act freely in the methods and finally to align them, so that both the methods capture the same performance.

The decline of correlations in SS at academic track schools might be attributed to a mechanism akin to the Expertise Reversal Effect (Kalyuga et al., 2003). Since an increase in expertise, i.e. growing familiarity with the methods, coincides with the gradual decrease of observable correlations, it might be argued that having overcome initial inhibitions students feel overly self-confident about their abilities and operate the methods with less care. As this interpretation relies on a single case, its character is admittedly rather speculative.

Finally, the test scores from the NAW-tests were correlated with the performance scores from video analyses. Analyses could reasonably be run only with the test for the CR-experiment, since psychometric properties proved to be acceptable for this test instrument only. The observed correlations are displayed in table 4.

Table 4 – Rank correlations between performance measures from video analyses and NAW-test (MC)

		total	**academic track school**	**comprehensive school**
video/NAW (CR)	r_S	.313*	.491**	.202
	p	.015	.006	.283
	n	60	30	30

It can be seen that the anticipated criterion of r_S>.65 is not met in any sample. This means that the hypothesis of the NAW-test being a suitable surrogate for direct observation needs to be rejected. Investigating the reasons for the low correlations more closely, however, gives rise to the idea that principally the NAW-test might be a suitable instrument. With regard to the observed average difficulty of the experimental task, the test items respectively, it becomes obvious that both the instruments lie at opposed ends of the difficulty scale ($P_{experiment}$≈.20; P_{NAW}≈.80). This means that while working successfully on the experiments is very difficult for the students, solving the test items is considerably easier; correlations between thus differently sensitive instruments cannot reasonably be expected to be positive and strong. Additionally, reduced reliability coefficients hint at a less systematic survey than anticipated, therefore, detection of systematic correlations is inherently hindered. Taken these two aspects into account and honouring the fact that, again, this interpretation relies on a single observation, it is possible that, provided the psychometric properties of a test are good and its difficulty is more aligned with the connected experiment, MC-tests might after all be capable of measuring students' achievement in experimental processes. Even as it is, correlations between the NAW-test and the CR-experiment are of a medium strength for academic track students, which promises potential for improvement when using more reliable instruments.

CONCLUSION

This study aimed at identifying instruments that can be used to assess students' achievements in experimentation with a focus on the process. It, therefore, employed a shared process model of experimentation in all the administered instruments and controlled for known influences (e.g., theme, sequence, repeated measures). Analyses could confirm that open reports are favoured as surveying instruments over closed MC-tests. It could be shown, too, that students need time to master the open report format before it can serve as a substitute. Data for the closed MC-tests suggest that there is potential in using these tests as an alternative assessment but psychometric quality needs to be controlled more thoroughly as well as the adjustment to the level of difficulty between competing measures. These findings are in line with earlier work by Shavelson (e.g., Baxter & Shavelson, 1994; Shavelson et al., 1999) but add the perspective of an analysis oriented at a process model of experimentation, which so far has not been respected strictly.

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STUDENTS' SCIENCE COMPETENCES AT THE SCHOOL OF BIOCHEMISTRY AND BIOLOGICAL SCIENCES - UNL-ARGENTINA

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Abstract: PISA report concerning the acquisition of science competences by adolescents of several countries in the world, including Argentina, revealed alarming results. These results led us to wonder: What happens at university level in Argentina?

The results of this paper show what science competences students have when they start attending the School of Biochemistry and Biological Sciences at Universidad Nacional del Litoral (first year of the Biochemistry and Biotechnology courses) in Santa Fe (Argentina) and what competences they have when they finish university (fifth year of the same courses) for their professional integration into the labour market.

Two questionnaires were designed to gather data. One of them was an adapted version of PISA tests and was used to learn about the students' science competences; the other one was used to examine the influence that certain contextual factors might have had on academic performance.

Analysis instruments were also designed for the transformation and categorization of the data in order to find regularities in the competences and in the contextual factors.

From the results obtained in this research, it has been possible to identify: the scientific competences which students have when they enter and leave, as well as the similarities and differences between them; certain characteristics in the university *currícula*, concerning mainly the Chemistry courses, which could provide guidance on priorities for a qualit y education that fosters the development of researched competences; and some of the socio- cultural context factors that influence student's performance in science.

Keywords: science competence, university education.

BACKGROUND, FRAMEWORK AND PURPOSE

Nowadays, science education is expected to provide scientific knowledge, the appreciation of the importance of the contribution of science to society and a more effective preparation of our young students to participate fully in society. To achieve these aims, a critical attitude and a reflective approach to science are vital (Millar and Osborne, 1998).

PISA 2006 assessed different competences but focused on *Science Competences* and highlighted the need to develop innovative teaching approaches which would contribute to the enhancement of education quality. It also emphasized the need to centre on how and with which aim this knowledge is used (OCDE, 2006).

Thus, PISA focuses mainly on scientific literacy rather than on the command of curricular content (Bybee, 1997; Harlen, 2002); that is to say, it gives more value to the ability to solve problems than to memorize knowledge.

Argentina participated in PISA 2006 as a partner country together with other 56 countries. The results obtained by Argentinian young people (15 years old) were alarming. Argentina ranked 51st, obtaining 391 score points, significantly below the OECD average of 500 score points (OCDE, 2008). In the more recent 2009 study, Argentina participated with other 64 countries and the results indicated a negative evolution. In the assessment of science competence, Argentina ranked 56th, obtaining 401 score points, significantly below the OECD average of 501 score points (OECD, 2010).

Having said this, we agree with Monereo *et al.* (2009) that it is necessary to improve our education system. Analysis of PISA results can provide the opportunity to do so. Therefore, it seems to be relevant to carry out research into what happens at university level in Argentina

Rationale

In the new *currícula*, competence-based education and the learning context have assumed major importance. Therefore, the **aim** of this research is to study what science competences students have when they start attending the School of Biochemistry and Biological Sciences at *Universidad Nacional del Litoral* (first year of the Biochemistry and Biotechnology courses) in Santa Fe (Argentina) and what competences they have when they finish university (fifth year of the same courses) for their professional integration into the labour market. To examine whether students have acquired those competences, their capacity to reorganize what they have learnt and transfer that knowledge to new situations and contexts will be assessed (Perrenoud, 2004; Zabala & Arnau, 2007).

In consonance with the aim stated above, the following **Research Questions** have been posed: What science competences do students have when they start their Biochemistry and Biotechnology courses and which are the ones they have acquired by the time they finish university? What are the similarities and differences between the science competences of the first year students and the science competences of the students who have completed their fifth year in both university courses? What science competences are relevant for the design, implementation and evaluation of quality education? How does the socio-cultural context affect the students' performance in science?

METHODS

Subjects and sample characteristics: a sample of 122 students was studied: 63 students of Biochemistry (47 first year students and 16 fifth year students) and 59 students of Biotechnology (37 first year students and 22 fifth year students). Selection was done based on a stratified sampling design to find homogeneity within each stratum and heterogeneity between the strata.

Data gathering instruments: two questionnaires were designed and students were given one hour to complete them. Information was thus gathered in writing.

- *Science Competence Questionnaire:* this questionnaire was designed by selecting some questions in PISA 2006 and adapting them for university level. Three levels of description and interpretation of chemical knowledge deemed to be desirable from an academic point of view in a variety of situations were examined: microscopic, macroscopic and symbolic. The science questionnaire consisted of 17 questions divided into 2 units: *acid rain* (10 questions) and *caries* (7 questions). Each question was awarded 2 points as a maximum score and 0 point as a minimum. Some of them got a partial score of 1 point. *Cronbach's alpha* was used to measure the degree of reliability of the instruments.

- *Questionnaire about the Context:* this questionnaire was designed in order to get information about the following factors: age, gender (inferred from the subjects' names), hometown, secondary school they attended (the specialized area of study or orientation and whether it was a private or a state school) and their parents' educational background and occupation. The aim was to know whether there were any characteristics of the students' socio-cultural context that may have affected the students' performance in science.

Instruments for the analysis of the information: it is understood that people have different degrees of *science competence* and that no one lacks this competence in absolute terms. Therefore, results have been grouped together according to the three levels of science performance quantified by Biggs (2005, p. 236): maximum (100-70 %), medium (70- 50 %) and low (< 50 %). To analyze the performance in *science competences* the baseline was 50% of the total score.

RESULTS

Science Competence Questionnaire:

Scores for each science competence are reported in **Table 1**, together with the percentage of students at each proficiency level. The table comprises the following taxonomic categories: OSP: *overall science performance*; ISI: *identifying scientific issues*; EPS: *explaining phenomena scientifically* and USE: *using scientific evidence*.

Score	% Biochemistry students		% Biotechnology students		Competences
	1st year	5th year	1st year	5th year	
Maximum Level (% score obtained 100 to 70)	0,00	12,50	0,00	9,10	*OSP*
	17,02	43,75	13,51	31,82	*ISI*
	0,00	0,00	0,00	4,55	*EPS*
	6,38	56,25	2,70	22,73	*USE*
Medium Level (% score obtained 70 to 50)	23,4	56,25	2,70	50,00	*OSP*
	42,55	25,00	35,14	31,82	*ISI*
	17,02	37,50	8,11	50,00	*EPS*
	63,83	43,75	64,87	54,55	*USE*
Low Level (% score obtained < 50)	76,60	31,25	97,30	40,90	*OSP*
	40,43	31,25	51,35	36,36	*ISI*
	82,98	62,50	91,89	45,45	*EPS*
	29,79	0,00	32,43	22,72	*USE*

Table1. Students' science performance

As it is shown in Table 1, the number of students reaching the maximum level is very low in all categories. However, at this level, in the 5^{th} of Biochemistry there is a significant percentage in *ISI* and *USE*. In the 5^{th} of Biotechnology the increase is smaller and is associated with a marked decrease in the low level and a constant value in the medium.

Concerning to *EPC*, it should be noted that only 4,55 % of students in the 5^{th} of Biotechnology, having been trained for five academic years, reached the maximum level in the category of *Explaining phenomena scientifically*.

If we focus on students of 1^{th}, the data are devastating, with high percentages of students below the basic level set, except for *USE* where the highest percentage is in the medium level.

In relation to the *OSP*, only the half of the students, near to be professional, achieves the average level established.

Questionnaire about the Context:

For the sake of brevity, the tables with the corresponding data are not included. Data on the subjects' socio-cultural level and background was classified into the following taxonomic categories: *Personal Factors:* hometown, age, university year and gender; *Institutional Factors*: secondary school and the specialized area of study or orientation and *Family Factors*: parents' educational background and occupation.

CONCLUSIONS AND IMPLICATIONS

Even though generalizations cannot be made outside the context of this study, it is possible to draw some conclusions regarding the research questions this study sought to answer.

As regards the first two research questions:

In terms of *overall science performance* (OSP); first year students of both university courses obtained low values. In the last years, after instruction, these values increased and especially in Biochemistry.

In reference to *identifying scientific issues* (ISI, focused on aspects of the methodology of science); presented the best results. Biochemistry achieved highest scores in the different stages of study. After instruction, the fifth of Biochemistry achieved further development of this competence than the fifth of Biotechnology.

Explaining phenomena scientifically (EPS, focused on the application of scientific concepts); is probably the most traditional worked competence in the classrooms of science courses as Chemistry. However, it presented the lowest values in the four studied groups. It appears that instruction in Biotechnology develops and increases more this ability, because the last year of this course obtained a higher score.

In connection with, *using scientific evidence* (USE, focused on evidence and argument); both first years have similar values. Subsequently, the results improve with the instruction, though this is the competence in which there are the major differences between the years of study of both courses. It appears that instruction in Biochemistry develops and increases this ability.

Regarding the third research question:

From the analysis we have just made it can be concluded that, in addition to preserving what is already well done, performance could improve if into the instruction would incorporate activities that promote the development of the following:

- To identify relevant scientific questions through tests or scientific procedures.
- To focus on qualitative scientific explanations.
- To work on scientific and symbolic text typology.

As regards the fourth research question:

The results presented can confirm the multicausal character of academic achievement in science, since there are multiple variables that affect them.

In this sense, some links could be established between the results the students obtained in the tests and the personal, institutional and family factors. Without attempting to draw any definite conclusions, it can be identified the following approaches:

- Women get a score slightly higher in science performance than men in the first year and lower in the fifth.
- The educational level of mothers and fathers are factors that are positively related to the results of the tests in science. That is, the conditions of the family environment have an important influence on student performance, although in this study were not absolutely decisive.
- The school obviously affects the acquisition of knowledge. In this sense, the number of hours of science classes and the state schools are issues that contribute to increased student achievement.

All analyzed factors influence students achievement. Coherently with other studies in this area, assert the complexity of the factors associated with performance.

The definition of grades and types of competences can help to diagnose issues that need attention in the analyzed courses. In response to the discovered difficulties, we think of other new lines of work:

- To carry out a longitudinal study into first-year students throughout both courses.
- To design and evaluate educational strategies and teaching proposals that can help students to improve their science competences.
- To study the epistemic levels of arguments, when students answer open questions.
- To validate the test by external methods (cyclical evaluation), that would facilitate the monitoring of the adopted innovations results.
- To search scientific tools to be able to say, as accurately as possible: what is going wrong when the results are low and what is being well done when the test scores improve?

In view of the results obtained in this work, and from the results that could be obtained from the new lines of research that it suggested above, it could consider which profiles are desired for students graduating from Secondary Education, future citizens and future professionals who graduate from the University. In sum, the prospects of education in Latin America (Tuning Project, 2007).

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PROBING STUDENTS' UNDERSTANDING OF THE CONCEPT OF ELECTROMOTIVE FORCE IN INTRODUCTORY PHYSICS COURSES AT UNIVERSITY

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Abstract: This work is part of a research programme on teaching electromagnetism in classical physics. A study on the meaning that future secondary science teachers hold on the concept of electromotive force (emf) within the context of electrical circuits was carried out five years ago. In this work, we will explore in detail how first year university students understand the role played by the emf concept and its meaning in the electromagnetism context within classical physics. The need for information on students' alternative conceptions and forms of reasoning is particularly necessary in areas of the curriculum that have barely been researched due to their type of contents or the level of teaching. To study students' learning difficulties, a questionnaire was designed with three questions within the context of electrical eddy currents in a circuit. The questions are open so that the students have the chance to argue and justify their statements. Students' difficulties seem to be strongly linked to the absence of analysis on variation of the magnetic flux. Most students still do not clearly understand the usefulness of and difference between the concepts of potential difference and emf.

Keyword: learning electromotive force concept, university level, assessment of students' learning.

1. BACKGROUND AND PURPOSE

Measurement of the impacts of traditional teaching in introductory physics is a primary source of data for physics education new proposals. A key question which has been largely investigated in different areas of physics is whether students understand the taught theories and concepts in scientific way. Much work has been done in the past decades in considering the way students approach electrical circuits. Much of this research took place at secondary level. For example, previous studies find that secondary students consider that the current is spent as it passes though a bulb or that the current provided by the battery is independent of the topology of the circuit (Shipstone et al., 1988). Closset (1983) showed that many Secondary and University students analyse the circuit using "sequential" reasoning. This reasoning consists of considering that there is a variable denomination entity, the "current", the "electrons" or the "electricity" with which magnitudes such as intensity or tension are associated. It comes out of the battery and it is more or less affected as it passes through each element of the circuit, for example "the current is used in the resistor" or "the current is spent in the bulb". There is no back dating effect for what might happen to the "current" before the element or after the element; nor does it consider how it returns to the other pole of the battery. Liegeois & Mullet (2002) showed that secondary students have difficulties interpreting resistors connected in series and in parallel in a complete dc circuit.

Duit, Niedderer and Schecker (2008) found three critical areas of deficiencies in students concerning electrical circuits: a) local and sequential reasoning versus global reasoning; b) conceptual understanding of the relationships between current and voltage; c) Ability to apply central relationships in problem solving. Other studies, for example Psillos et al (1988) and Testa et al (2006), are consistent with these general conclusions and found that the concepts of electrical potential and potential difference are frequently confused with the concepts of current intensity or energy, representing the “strength” of a battery. In addition, students frequently do not understand that the potential difference in a circuit depends on its topology. Most of these difficulties seem resistant to traditional teaching of electrical circuits.

Very few studies about assessment of students’ understanding on another concept related to potential difference but with a different physical nature such as the concept of electromotive force (emf) have been made (Varney and Fisher 1980). However, the emf concept is relevant to curriculum of electromagnetism because the following reasons. Firstly, this concept is included in most non compulsory high school programmes (students aged 16-18) and in introductory university physics courses. Secondly, the concept is fundamental to explain the energy balance in direct current circuits and in eddy current circuits. Thirdly, the diversity of contexts where the emf concept is applied makes it necessary to have an appropriate understanding of this concept and to know how to differentiate it from other concepts, related to it but with different meanings such as the concept of potential difference.

In a previous study we have analysed the epistemological context of developing the emf concept and its meaning within the theoretical framework of classical physics (Guisasola et al., 2008). We have found also that High School and University students do not clearly understand the usefulness of concepts of potential difference and emf in the context of dc electric circuit (Guisasola & Montero 2010). In the present study we are interested to determine whether university engineer and physics students who had studied electromagnetism really were able to apply and understand the concept of electromotive force in the context of electromagnetic induction in a circuit. Because this is a collaborative work among three universities from Spain, Belgium and Colombia, we have the opportunity to determine the similarities and differences between students studying physics in these three countries while assessing students understanding on electromotive force.

Spanish, Belgian and Colombian first year physics or engineering students had covered mechanics and electromagnetism subjects during a 2-year period and with a level similar to A level courses in the UK. They also had completed the first semester of scientist or engineering sequence, which focuses on classical mechanic, and had just finished electromagnetism (E&M) program in the second semester. In the three universities the curriculum of E&M is similar to standard programs for introductory physics courses and the used textbooks involves the same sequence of topics (Tipler and Mosca 2004 in Spain and Colombia; Young and Freedman 1996 in Belgium). All students received similar amount of lectures and they have also laboratory. The emf concept is taught by experienced teachers form the physics department in the chapter of dc circuits and in the chapter of electromagnetic induction in a similar amount of hours.

2. RATIONALE

The general theoretical framework for research on alternative conceptions, proposing that prior knowledge and students' conceptions interfere and affect their learning in new contexts, has been used extensively in the literature (Duit and Treagust 1998). However, learning physics and understanding the concepts does not only depend on conceptual understanding but also on the students' ontological and epistemological assumptions that affect the learning processes (Vosniadou, 2002). This research approach is based on the constructivist learning paradigm, which states that both students' prior knowledge and students' conceptions interfere with their learning in new contexts and affect it. This study follows the constructivist epistemology that recognises knowledge of the nature of science as personal and that includes social construction of knowledge to give meaning to observations and natural phenomena (Leach and Scott, 2003).

The need for information on students' alternative conceptions and forms of reasoning is particularly necessary in areas of the curriculum that have barely been researched due to their type of contents or the level of teaching. Although the concept of emf is important, both due to its role as a basic prerequisite for analysing electromagnetic phenomena produced by non conservative fields from an energy point of view, and due to its meaning in technological applications, there is very little research on it in the context of electromagnetism teaching.

3. METHODS

To assess students’ understanding of electromotive force in the context of electromagnetic induction a questionnaire was designed with three questions. The above mentioned approach shares a common form of making a type of questions that require that students don't only merely repeat the theory taught in class but demand the significant application of such knowledge. Therefore, the questions designed place an emphasis on the students’ explanations. Furthermore, the questions are open so that the students have the chance to argue and justify their statements. The questionnaire was given to engineering and physics students from Spain (N=77), Belgium (N=85) and Colombia (N=64), after they had studied the subject in class.

The answers were analysed according to the indications by Miles and Huberman (1994) quoted in Cohen et al. “Research methods in education” (2007). More specifically, three strategies were used: 1) Coding the frequency with which certain ideas or topics appear; 2) Noting down the patterns that can come out of these ideas or causal explanations; 3) Grouping the main items noted down into categories. One member of the research team came up with a draft set of description categories for each question, based on reading the students’ answers. This researcher then reread the students’ answers and tentatively allocated each answer to one of the draft categories. The other researchers carried out this task independently. Once the answers had been classified, answer category allocations were compared. The original categories were redefined until a consensus was reached. Any disagreements about category description or allocations of answers were resolved referring to the answers as the only evidence of students’ understanding. The focus was on the students’ understanding, taking the students’ answer as a whole, rather than focussing on the occurrence of particular statements corresponding to a specific category description. An iterative process was followed to produce final category descriptions that reflected the similarity in understanding among the answers allocated to each category and differences between the categories.

4. RESULTS

The questionnaire was designed in agreement with two of the primary goals in the international standard teaching curriculum for introductory physics courses within the topic of electromotive force. One of the primary goals is that students understand that Electromotive force means the work per unit charge done by non-conservative forces for producing electrical current or for separating charges. The quantity of emf is unique (independent of the physical context) and it measures the work done by non-conservative forces to transfer energy from any energy (Chemical, electro-magnetical) to electrical energy. The second goal is that students understand the difference between electromotive force and potential difference results from measuring different types of action produced by radically different causes. The electrical potential measures the work per unit charge done by coulomb forces. Regarding these teaching goals, in questions Q1 and Q3 students have to discuss the meaning of electromotive force concept in two different contexts (electrical circuits and induced current circuits). The correct answer implies to conclude that the meaning of the concept is the same but the way to calculated it changes depending on the context. The questions were presented as follows:

Q1.- The study of electric and magnetic phenomena considers the electromotive force of a battery and the electromotive force of induction in different chapters. Two students make the following statements:
E1: this refers to the same concept; the only thing that changes is how to calculate it in different contexts.
E2: These are two different concepts. The first considers the electromotive force in direct current circuits and the second considers electromotive force in electromagnetic induction phenomena.

Indicate which of the two students is right and explain carefully why.

Q3. Figure 1 shows a direct current electric circuit with a 12 volt battery as the electromotive force. Figure 2 shows an eddy current circuit that has an electromotive force of 16 volts.

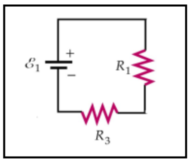


Figure 1

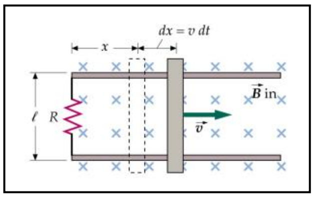
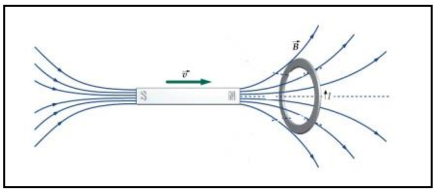


Figure 2

A student states that: "although the two electromotive forces have the same unit, they correspond to two different physical concepts”. Do you agree with the student? Give ***reasons*** for your answer:

The objective of Q2 is related to the second teaching objective. Students have to discuss the difference between the potential difference concept and electromotive force concept based on the work done by conservative and non-conservative charges. The question was presented as follow:

Q2.- When a magnet travels at constant speed closer towards a loop at rest (see diagram), an electric current is induced in the loop. Explain whether the following statement is correct:
"A potential difference has been induced and therefore an electric current appears in the ring."



The results and its categories are showed in the table:

Categories	Q1			Q2			Q3		
	Sp. (77)	Belg (85)	Col. (64)	Sp. (77)	Beg (85)	Col (64)	Sp. (77)	Belg. (85)	Col. (64)
A. Define correctly the meaning of emf	19.5%	7%	19%	8%	7%	8%	20%	3.5%	6%
B. There are two concepts of emf									
B.1. Reasoning based on the "cause" that produces emf	35%	19%	20%	8%	-	8%	37.5%	37.5%	24%
B.2 Reasoning based on the context	23.5%	12%	26.5%	-	-	-	12.5%	10.5%	28%
C. There is confusion between emf and pd	2.5%	15%	6.%	45.%	42%	42%	4%	15.5%	14%
D. 'Ad hoc' arguments are applied with false reasoning or based on poorly memorized data	8%	19%	17%	31%	46%	30%	14.5%	12%	20%
No answer	11.5%	28%	11%	8%	5%	12%	11.5%	21%	8%

There is a minority of answers in category A. Few students focus on the role played by the electromotive force as a magnitude which measures the work per unit charge done by non-conservative forces for reorganising the charges, producing a potential and, in the case of circuits, producing a electrical current. There are variations between the different groups of students but the correct answers are not exceed 20%. In addition, when the question focuses on highlighting the role played by non conservative forces in the definition of emf, the percentage drops and does not rise above 10% (question Q2). When we analyze the answers the criteria is to consider "correct answer" (category A) in a "wide sense" of meaning. Some examples of this category are showed following: "Student E1 is right as the electromotive force is the work per unit charge that is carried out to move the charges. This definition does not change and so the concept of electromotive force is the same as calculated differently in a circuit or in the induction" (Q1, Spain, first year engineering); "Student E1 is correct as the concept of electromotive force is the same. As the emf produced by the battery and the induction emf are produced differently, you have to calculate them differently but the concept is the same" (Q1, Colombia, first year physics). "Correct. In fig 1, the emf comes from the battery and is simply caused by the potential difference. In fig 2, the voltage is caused by the moving bar in a magnetic field" (Q3, Belgium, first year engineering).

Roughly the half of the answers in questions Q1 and Q3 explain that emf concept has two different meanings. In order to justify one concept has two different meanings, the students use two different strategies:

- A justification base on the ‘cause’ (category B.1). The students’ reasoning explain the emf from the effect that is generated in electro-kinetics, whereas the explanation for the induced emf is from the way in which it is generated (the emf is caused). The students’ understanding is interpreted as two different concepts because its “cause or origin” is different. When describing this cause, it is done by an explanation of “how” or of “what”. Two examples explain this category: “It is not the same to talk about electromotive force in a close circuit as in induction. In a closed circuit, the emf is constant and produced by the battery and in the induction, the emf depends on the magnetic flow and the time” (Q1, Colombia, first year physics); “Correct. In the second case, it is about a change in flux in the bar. In case 1, it is about a battery voltage, so chemical energy which is converted to a potential difference” (Q3, Belgium, first year engineering).

- The category B.2 can be considered as a generalization of B.1, in the sense that students’ explanations do not use a causal reasoning for distinguish two meaning of emf, but they differentiate two different emf due to characteristics from the context where it is produced. For example: “Students E2 is correct. The first case is an electromotive force generated by a battery. The second case is an electromotive force generated by an induction phenomeno” (Q1, Spain, first year engineering); “They are two different concepts as one refers to the emf of a circuit and the other refers to a magnetic induction phenomenon” (Q3, Spain, fist year engineering).

- A significant proportion of the answers in this category B (56% in Belgium and 21% in Spain) use concepts of electromotive force, voltage and potential difference as synonyms in their explanations. This can imply that the students do not have their own meaning for each concept and that they do not differentiate them as concepts that measure different physical phenomena. This confusion appears clearly in category C of questions Q1, Q2 and Q3. One example of this type of explanation: “Student 2 is correct. Of course, in both cases, it is about a voltage but a battery always delivers a direct voltage, and direct current and can be computed by $\varepsilon = IR$. An induced voltage is caused by a change in magnetic field/flux. Therefore this voltage is not always constant, because if the magnetic field does not change, there is no ε and the value of ε depends on the change of φ, as $\varepsilon = d\varphi/dt$” (Q3, Belgium, first year engineering)

A half of the answers of the question Q2 explicitly indicates a mix up between emf and potential difference (category C). For example: “Upon introducing emf, a variable potential difference is induced in the ring” (Q2, Colombia, first year physics); “Yes, it is correct. As the magnet moves closer to the coil, it produces a current and therefore difference in potential” (Q2, Spain, first year engineering); “This is true. As the magnet moves closer, the field lines passing through the coil increase and an electric current is induced, meaning a potential difference. $\Delta V = I\,R$” (Q2, Spain, fist year engineering).

5. CONCLUSIONS

Students’ difficulties seem to be strongly linked to the absence of analysis on the work carried out by conservative and non-conservative forces on the phenomena and its energy balance. Concurring with results from other investigations (see background) and our previous results, it can be interpreted that when the context is within electrical circuits, the majority of the students are not clear on what emf is, and therefore the battery is talked of as a generator of emf, much like a “black box”. For that same reason, they do not talk of transforming chemical energy into electric, nor the non-conservative field …etc. On the other hand, in the context of induction, the stress is on the cause that generates emf (variation of magnetic flow in time) describing how it is generated. From this perspective, as the majority of the students have the “causes” that produce the emf as different, the concepts are also different.

Most students still do not clearly understand the usefulness of and difference between the concepts of potential difference and emf, not in situations involving direct current circuits and not in eddy current circuits.

In all cases, we found evidence that Students’ difficulties are strongly linked to the lack of meaning of emf. The results of the study show that teaching will be explicitly points out some conceptual key aspects of the electromotive force such as: a) electromotive force is related to work made for moving charges; b)The magnitude of emf is unique and it measures the work done to transfer energy from any form (Chemical, electro-magnetical) to electrical energy; c) it will be necessary to justify that the difference between electromotive force and potential difference results from measuring different types of action produced by radically different causes. Consistent with a constructivist approach of teaching and learning, which take into account students’ conceptions, teachers would not only teach based on straightforward transfer of concepts and laws with illustrations of ‘ad hoc’ examples; it will be necessary to design learning sequences that do not just explain the key ideas already mentioned but which also use a teaching strategy which gives students the opportunity to use scientific procedures such as putting forward hypothesis about the relevance of a model for the problem proposed, suggesting a number of different strategies to explain it and justifying the answer based on evidence.

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STANDARDIZATION IN PHYSICS – FIRST STEPS IN THE AUSTRIAN EDUCATIONAL SYSTEM

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Abstract: The definition of standards and the development of competence models in science education has been one major endeavor in several European countries during the last decade. Like in many other countries, this issue was also brought up in Austria, due to low results in international student assessments (PISA, TIMMS). In 2007, a project group was installed by the Ministry of Education to implement national educational standards for science (grade 8). The objectives for the implementation phase (2007-2011) were the development of a competence model for science and of a pool of archetypal tasks to exemplify and evaluate the model. In a series of 5 pilots (N_{min}=3597; N_{max}=8559) archetypal tasks were assessed in form of a paper & pencil test (1st pilot) and online tests (pilots 2-5). Up to now, a normative competence model for the subjects biology, chemistry and physics was developed and operationalized in 70 archetypal tasks. Interim results suggest that those tasks so far developed, cover a wide range of the competence model. Additionally, there are hints that they indicate competence (in Weinert's (2002) concept of competence) rather than content knowledge.

Keywords: Standardization, Competence, Physics, Archetypal Tasks

1. INTRODUCTION

The definition of standards and the development of competence models in science education has been one major endeavor in several European countries during the last decade (Waddington *et al.* 2007). This issue was also brought up in Austria due to moderate or even low results in large scale student assessments like PISA, or TIMS. One strategy of reaction was to develop and implement educational standards to change the focus of the educational system from input-orientation to output orientation.

In general, standards specify students' competences at a certain grade and describe the expected learning results. Focus is put on the basic concepts of a subject. In Austria it was agreed upon performance standards handled as regular standards, which are supposed to describe a regular level of demands.

Normative competency models, based on Weinert's concept of competences (Weinert 2002), should serve as a starting point for the process of standardization in Austria. According to Klieme et al (2003), normative competence models have a kind of bridging function between the abstract goals of education and the concrete problems students are expected to solve.

As second theoretical basis served the concept of scientific literacy as used in 2004's Learning for tomorrow's world: "The emphasis of the PISA 2003 assessment of science is on the application of science knowledge and skills in real-life situations, as opposed to testing particular curricula components. Scientific literacy is defined as the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.“(Programme for International Student Assessment, 2004)

2. IMPLEMENTATION PROCESS OF SCIENCE STANDARDS IN AUSTRIA

In 2004, the Ministry Education initiated the implantation process for educational standards for the core subjects in grade 4 (German, mathematics) and in grade 8 (German, mathematics, English) (Lucyshyn 2004). In 2005, a start was made to develop standards for science subjects for the vocational school system in grade 12 and in 2007 for the lower secondary level in grade 8. In the following, working groups for all subjects, consisting of experienced teachers, educational researchers and representatives of the Ministry, were appointed to develop competence models.

Einhaus and Schecker (2007) have suggested the following 3 stages for the development of a competence model for national educational standards:

(1) development of a normative competence model as basis for further research
(2) development and validation of a suitable test instrument for the competence model
(3) verification of the normative competence model and adaption according to the structure of students’ abilities by empirical data.

Austrian policy makers, however, decided that the development of the competence model for science should not be directly succeeded by the construction of psychometric tests. Instead, the project group were to construct and assess archetypal tasks (Labudde et al. 2009) after developing a normative competence model for science.

The implementation process of science standards grade 8 in Austria was also planned in three main phases. Some differences to the procedure suggested by Einhaus and Schecker (2007) can however be noted: As in many other countries the first step was to develop a normative competence model for science subjects 2007 (Weiglhofer 2007).

The second step differed form common procedures of standardization. The emphasis was not put on a psychometrical valid test instrument, but rather on the development and evaluation of so called “archetypal tasks” in a series of 5 pilots between 2008 and 2011. The creation of archetypal tasks aimed at two different goals. One was to exemplify the dimensions of the competence model to teachers, since archetypal tasks are instructional assignments rather than test items. So awareness should be created for instruction focusing on competences instead on mere content knowledge. The second aim was to improve the competence model for science subjects itself based on the empirical data collected by piloting archetypal tasks.

Finally, a third step was planned for the development and validation of psychometric test items and nationwide baseline tests. The schedule for phase 3, however, is still open.

3. RESEARCH QUESTIONS & METHODS

The standardization project contained a huge number of research questions. The main research questions discussed in this contribution focus on two different target groups, students and teachers. Research questions on the level of students were:

- To what extent are students able to solve archetypal tasks?

- How do students rate the degree of difficulty of archetypal tasks?
- Is there a difference in performance between schooltypes?
- How motivated are students to do individual archetypal tasks?

On the level of teachers we were interested in the following questions:

- To which extent do teachers use similar tasks in their lessons?
- How do teachers evaluate the classification of the archetypal tasks within the normative competence model?

In a series of 5 pilots (2007-2011) a pool of PISA-like problems (archetypal tasks) based on the dimensions of the competence model was assessed. In each pilot phase tasks of each subject (biology, chemistry, physics) were grouped together into different task booklets. Besides these tasks, questionnaires for accompanying research were used. Students of adequate grade 8 samples worked on one booklet each. While the first pilot was administered in the form of a paper and pencil test, the following 4 pilots were assessed online.

The research process started in May 2008 with a nationwide assessment (N>6993) of one task booklet per subject (10 problems in total) in form of a paper and pencil test. In February 2009, 6313 students worked on three task booklets (10 problems in total, 1 booklet per subject).

In September 2009 the core project team was enlarged to 10 members for each subject. Based on the results of the first two pilots, archetypal tasks were refined and new ones were developed. In February 2010, in pilot three, 8559 students took part in the online assessment of in total 23 tasks, in 3 booklets for each subject and in June 2010, 3597 students worked again online on 27 tasks. The series of pilots was to be concluded in February 2011. Additionally, experimental tasks will be assessed by small samples.

4. RESULTS

The Austrian competence model for science year 8 was based on international models (eg. National Research Council, 1996; CMEC 1997; Bybee 2002; KMK, 2005). The resulting three-dimensional competence model is combined for the subjects biology, chemistry and physics (Weiglhofer 2007). It includes competences of acting (1st axis), three levels of complexity (2nd axis) and domains of contents (3rd axis), which are specified for each science subject separately. The spectrum of competences of acting consists of three main components: 1) observing & describing 2) investigating & interpreting 3) assessing & judging. For physics, five domains of content were chosen: mechanics, electricity & magnetism, heat, optics and properties of matter.

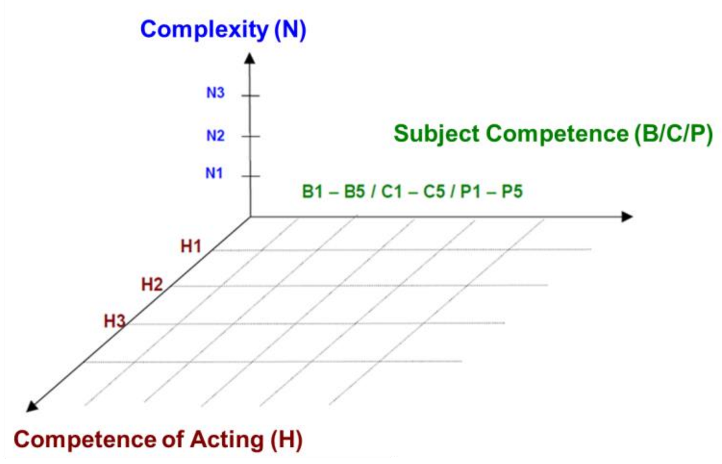

Figure 1: Austrian Competence Model

The archetypal tasks mentioned earlier represent knots in the competency model. The descriptors of these three dimensions are work in progress, they are fine-tuned with data collected in the pilots.

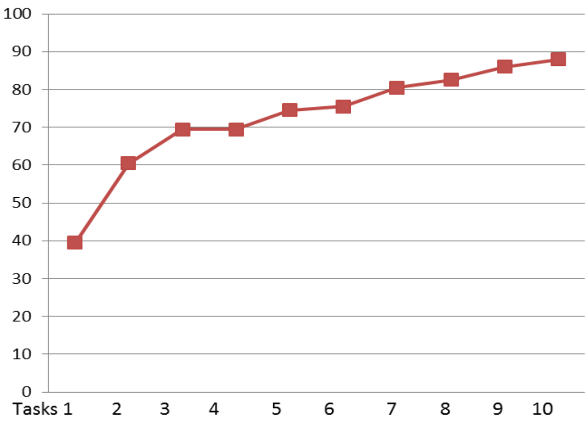

Figure 2: Solution Frequency in percent

In this contribution empirical data collected in the February 2010 pilot is presented. Solution frequencies of the tasks varied between 39,5% and 88,0%. Students assessed the difficulty of the physics tasks on a scale from 1 (=very difficult) to 5 (=very easy) as medium (M_{FEB}=3,01). Further findings are performance differences between students from grammar school and secondary modern school. Students from grammar school (Gymnasium) perform significantly better than students from secondary modern school (Hauptschule) on the basis of $p<0.05$. Students of secondary modern school regard tasks significantly more difficult than students from the natural science track of grammar school.

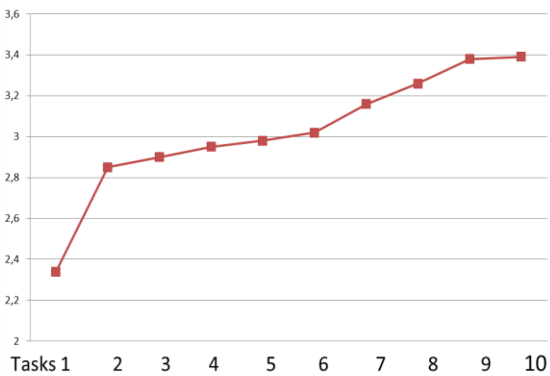

Figure 3: Difficulty assessed by students (1=very difficult, 5=very easy)

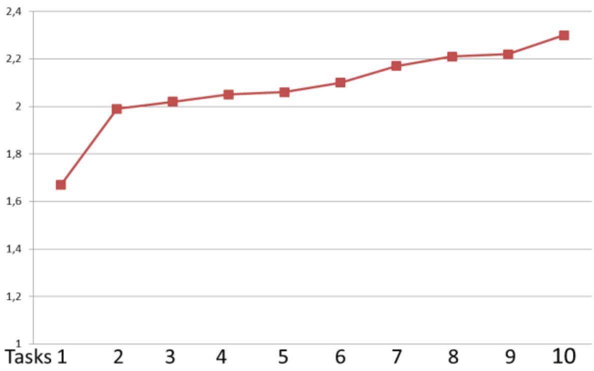

Figure 4: Students' motivation (1=low motivation; 5= high motivation=

The results of the teacher questionaires indicate that teachers hardy use tasks identical with the archetypal task for instruction. In most cases, the majority of teachers agree with the classification of archetypal tasks within the normative competence model.

5. Conclusions and Implications

In general, the research project science standards grade 8 has contributed to the discussion and definition of competences in science instruction and resulted in a normative competence model. The development and piloting of archetypal tasks set first steps in the evaluation of the competence model and served as opportunity to promote the idea of science standards among teachers. An additional benefit is the freely accessible pool of examples of good practice (archetypal tasks) for instruction and learning which can also be used as a diagnostic tool for individual student evaluation.

As far as the evaluation of the archetypal tasks is concerned, the range of the average solution indicates that a wide spectrum of competences defined in the competence model has been covered so far. Although the content of the tasks is in the majority of cases familiar to the students, students' achievement is for most tasks not correlated to their familiarity with the content. This may be seen as a first indicator that the archetypal tasks indicate students' cognitive abilities and skills to handle particular problems (Weinert 2002, p.27f) rather than their mere content knowledge.

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MEASURING EFFECTS OF NON CONVENTIONAL LABWORK

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Abstract: Laboratory learning environments are often criticized as not being effective. Research has only shown controversial effects of laboratory learning environments on students' learning, attitudes etc. Based on the criticisms a problem based, guided inquiry laboratory learning environment was developed to foster students' conceptual understanding. To assess the effects of this learning environment, a comparative study with a Pre-Post-Follow-Up-Design was carried out with N = 320 students from grade 9 and 10. Among the instruments used were knowledge tests, surveys on interest and self concept as well as an adapted version of SLEI. To study the processes during labwork, a smaller sample of lessons were videotaped and analysed with CBAV categories.
While the analysis showed, that students from EG outperformed CG by time spent on working on the experiments and discussing physics concepts, the summative measurements found no major effects of the intervention, neither for conceptual understanding nor for interest or self concept. Also the perception of the laboratory environment by students did not differ between the groups. The presentation will focus on the consequences of these results for measuring effects of non conventional laboratory learning environments.

Keywords: Laboratory learning; experimental competence; Assessment; Problem-Based Learning

INTRODUCTION

There are a lot of goals for the science laboratory. Most prominent among them is that students can get a better understanding of the science concepts by doing experiments. However the effectiveness of learning in laboratories has been criticized over many years. One of the most cited criticisms is that students are not fully engaged in thinking about their lab work while doing it. Instead they follow a list of tasks in a "cookbook"-style laboratory guide (Hofstein & Lunetta, 2004). Hence they miss the chance to get a better understanding. This may account for the negative results of empirical research on learning in the science laboratory. Most findings do not support that students working with experimental materials grasp science better (Singer, Hilton & Schweingruber, 2006). In a socio-constructivist view of teaching and learning, to enhance students' performance, these criticisms have to be changed to guide students towards active learning in the laboratory.
For this reason, a learning environment for the physics laboratory was developed, which takes into account the criticism of the literature. Adapting an idea from van Heuvelen (1995) a problem-based, guided inquiry approach was developed. Therefore a typical experiment from a grade 9 (introductory optics) respectively a grade 10 (introductory electricity) laboratory was reformulated into an "ill-defined" problem. E.g. instead of finding the right additional resistance for a voltmeter, the problem stated was to

measure an unknown voltage with an antique instrument without damaging it (fig. 1).

Figure 1: Get this phone (built for 3.8V) running with a 9V-battery. It will break, if you use higher voltage!

All of the problems were constructed in a way, that trial-and-error-strategies were not successful to solve the problem. To find a solution, students had to understand the problem, find out what experiments to perform and which concepts to use explaining their experimental findings. To foster students' interest in this kind of laboratory work, the problems furthermore were constructed in interesting contexts. In this way, a nonstandard laboratory learning environment (PBLL) was built.

To evaluate the effects of this learning environment, the following hypotheses were chosen:

(1) Students working with PBLL spend more time on the task and talk more about physics.
(2) Students' perception of PBLL is better than of traditional laboratory work.
(3) Students' conceptual understanding is promoted by PBLL.
(4) Students' interest is promoted by PBLL.

METHODS

To find answers, a comparative empirical study in 9^{th} and 10^{th}-grade classrooms was planned and carried out. In grade 9 (optics), 4 classes (n = 70) worked with PBLL at an average of 8 lessons, 2 classes (n = 55) worked with traditional laboratory guides for the same time. In grade 10 (electricity), 7 treatment classes (n = 184) worked with PBLL, 4 control classes (n = 101) did traditional labwork. The length of the intervention was 10 lessons. In Bavaria where the study was carried out, traditional labwork means the use of cookbook-style, laboratory guides (TL).

In all groups, questionnaires and knowledge tests were given as pre- and post-tests. In a smaller sample also a follow-up test was administered. Although a nonstandard learning environment was to be tested, a unbiased test could only be made using instruments proved valid in the literature for standard laboratory settings.

The questionnaire consisted of adapted and translated subscales of SLEI (Fraser, Giddings & McRobbie, 1995) and a subscale of CLES on personal relevance (Taylor, Fraser & Fisher, 1997) to measure students' perception of the learning environments. To track the development of students' interest, a instrument by Berger (2000) was adapted and administered. Students' conceptual understanding was measured with knowledge tests. These knowledge tests consisted of standard items (Herdt, 1990; Rhöneck, 2004), additionally selft-constructed items were used.

To document the process–of students' laboratory work, a small sample of students were videotaped. These videos were analysed in 10-second loops with an adapted version of the CBAV-category system (Niedderer, Tiberghien, Buty, Haller, Hucke, Sander, Fischer, Schecker, Aufschnaiter & Welzel, 1998). Furthermore, semi-structured interviews with students and teachers were held and field notes were taken.

RESULTS

The results of the empirical study are quite heterogeneous. The data from interviews as well as the analysis of the field notes showed that the developed material worked well in the classroom. All of the interviewed teachers and students liked PBLL and required the development of more learning environments like this. The field notes showed that all students had problems on their first encounter but soon got acquainted with the new approach and worked intensively.

These results are supported by the analysis of the video tapes. CBAV-Categories showed that in PBLL, students spent significantly more time on working with the experiment (fig. 2) and discussing physics respectively physical connotations of the experiment (fig. 3). These effects originated mainly from underachieving students. For high achieving students, video analysis from PBLL and TL did not show differences, neither in students' verbalisations nor their activities.

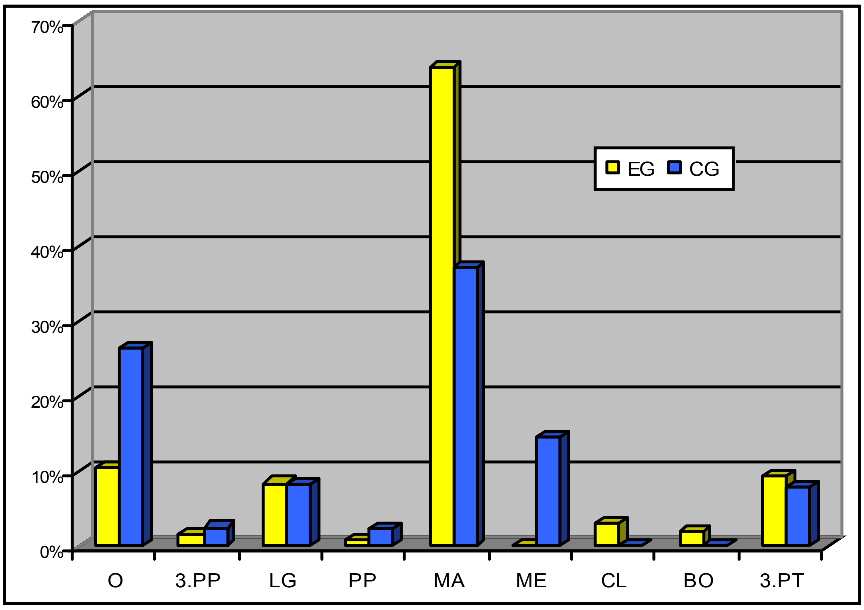

Figure 2: Students' activities (O: Other; 3.PT: Interaction with tutor; 3.PP: Interaction with peer; LG: Reading of lab guide; PP: Paper & pencil; MA: Manipulation of apparatus; ME: Measuring; CL: Calculation; BO: Using textbook)

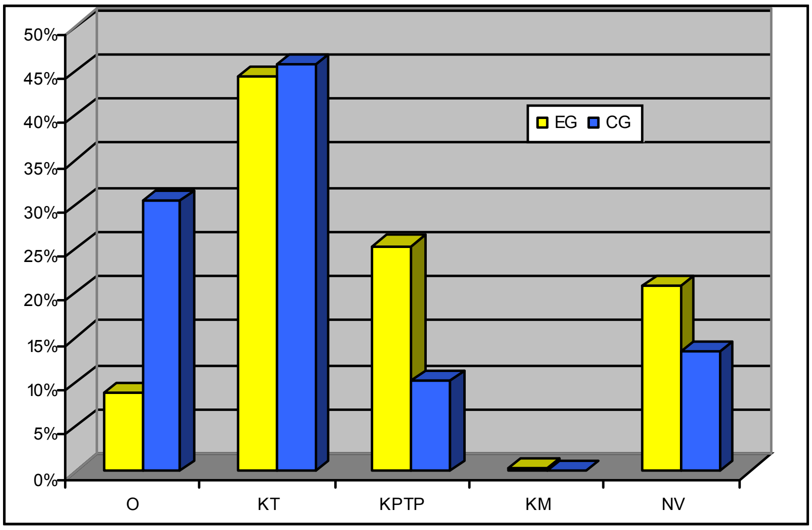

Figure 3: Students' verbal (O: Other; KT: Technical aspects; KPTP: Technical and physics aspects; KM: Mathematics; NV: No verbalizations)

A problem arose with the questionnaire. Only one out of the three used SLEI-scales could be replicated in the sample (student cohesiveness, $\alpha = 0.811$). Comparing pre, post and follow-up-tests, only minor differences between EG and CG could be found. Although all effects are in favour of PBLL, no significance could be detected. For both of the scales Open-Endedness and Integration of SLEI, Cohen's alpha yielded insufficient values. The scales 'Rule Clarity' and 'Material Environment' gave the impression not to fit the research questions and were not used in the study.

The scale 'personal relevance' from CLES could be replicated ($\alpha = 0.885$), but also in this scale only small effects for TG over the period of the study could be found.
On the two scales of interest (global interest for physics classes, $\alpha = 0.821$ and actual interest for doing experiments, $\alpha = 0,791$), small effects ($d = 0.1$ – $d = 0.3$) could be seen. Most interesting was that these effects are all due to a decrease of the CG values, not due to an increase in EG.
The results of the knowledge tests were heterogeneous. Whereas in 10th grade the TG outperformed CG slightly ($d = 0.25$; fig. 4), in 9th grade this happens the other way round ($d = -0.26$; fig. 5).

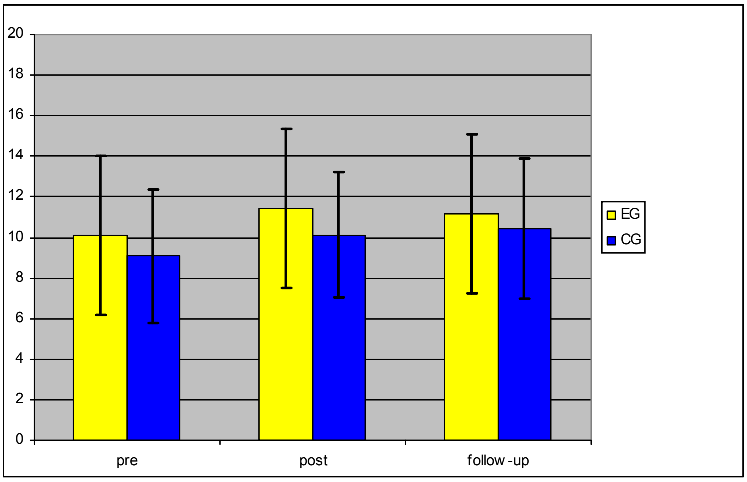

Figure 4: Understanding in Electricity, 10th grade, max. 20 pt

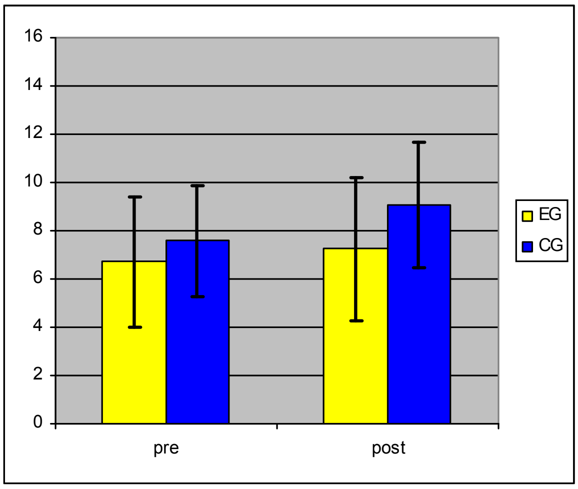

Figure 5: Understanding in Optics, 9th grade, max. 16 pt

CONCLUSIONS AND IMPLICATIONS

The conclusions from these results are ambivalent and several valid interpretations can be found. There are contradictory effects: on the one hand, with PBLL students work as planned. They experiment with the given materials, the time is much more on-task than in TL. Students talk about physics and its relation to their experimental data. On the other hand this has no sizeable effect on interest for experiments, on interest for physics lessons and on the perception of the laboratory environment. Furthermore – taken both grade levels into account – no effects on students' learning due to PBLL. Thus an old result of empirical studies on learning in the laboratory was replicated: The use of experiments per se does not lead to a better understanding of physics. But also a learning environment which takes all criticisms into account, does not lead to a better understanding of physics or to better student attitudes.

In my opinion learning physics is not directly influenced by the way the laboratory is constructed.
Another interpretation could be: The main aspect of the effectiveness of laboratory learning is its inclusion into the curriculum. For the reported empirical study, this was not the case. To assess the effects of PBLL versus TL it was decided, not to include the treatments directly into a physics course. But it was agreed to add it to regular physics classes. This may be a major point of critic against the results; in a replication of the study, this should be taken into account.
At last a third interpretation can be made: What happened in the PBLL resp. TL laboratories could not be measured by the reported instruments. Learning processes in the laboratory are much more complicated than to assess them with traditional knowledge tests or interest questionnaires. But the aim of the reported study was to evaluate the effects of PBLL exactly in these measures. A result is therefore, that there are no effects of different types of laboratory learning environments measured by paper-and-pencil-tests.

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DEVELOPMENT OF SCALE FOR ATTITUDE TOWARDS PHYSICS COURSE

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Abstract: The purpose of this study was to develop Likert type scale for measuring attitudes towards physics course while examining construct validity and testing the fit between independence model and the hypothesized model through confirmatory factor analysis (CFA) after performing exploratory factor analysis (EFA). Research's dates were collected seven high schools students in Center city in Edirne, 2006-2007 academic year, and spring term. Missing dates were taken part in data analysis. The Scale for Attitude Towards Physics Course (SATPC) was administered 865 students who 492 girl, 373 male. Students' age ranges change from 14 to 18 (M=15.78, SD =.82). It was considered that the scale of measuring attitude towards physics course had unidimension construct as the result of EFA and CFA was performed to analyze validation of theoretical construct for further analyses. Results show that the scale had unidimension construct. Accordingly, internal consistency reliability analysis and test-retest were performed. Cronbach alpha was .95 which indicates a high internal consistency. According to test-retest's results, the both measurements are significantly correlated with each other in high level (r=.76, p<.05). Finally, psychometric results of "SATPC" showed that the scale had construct validity and reliability.

Keywords: Physics Course, attitude, high school students, confirmatory factor analysis

INTRODUCTION

Researches suggest that there is a positive correlation between attitude toward science and science achievement (Mattern & Schau, 2002; George & Kaplan, 1998). According to Osborne, Simon and Collins (2003, p. 1053), attitudes towards science, "are the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves." There are four pillars of science education. These are "attitudes towards: (a) the science subject itself as a discipline; (b) the learning of the science subject; (c) topics and themes covered in a particular course (e.g., themes of social awareness); and (d) the methods of science (the so-called scientific attitude). Although much of the disseminated research has focused on the first target (Reid, 2006, p. 7), much of the work on attitudes has concentrated on attitudes towards the specific science area (usually physics, sometimes chemistry)" (Reid, 2006, p. 8).

As known, science consists of physics, chemistry and biology, and these disciplines function independently. Thus investigating attitudes towards physics, chemistry and biology independently is better than taking the general attitude toward science alone because students have different attributions towards these scientific disciplines. This will provide further information about students' attitudes towards science (Şengören, Tanel & Kavcar, 2007).

Many countries face significant problems with engaging students with the advanced study of physical sciences (Osborne & Dillon, 2008, p.13). Whereas many topics can be integrated to physics education (Juuti, Lavonen, Uitto, Byman & Meisalo, 2003, p.57) within the science, physics is considered as the most problematic area and it traditionally attracts fewer pupils than chemistry and biology (Reid & Skryabina, 2002, p. 67). According to Williams and his colleagues (2003, p.324), the major general reasons for finding physics uninteresting are that it is seen as difficult and irrelevant. And also because of the changing nature of physics over the secondary school period, physics becomes increasingly difficult, less descriptive and more mathematical (Owen, Dickson, Stanisstreet & Boyes, 2008). Literature addresses that the perception of a person as being difficult tends to result in the development of a general negative attitude to that subject (Williams et al, 2003, p.329), and this negative attitude may cause low achievement. This needs more additional research on attitudes toward physics.

To find reliable results without error, the researches and teachers have to use valid and reliable scales. When we look at literature, we can find many scales which measure "attitude towards science", but we can't find "attitude towards physics course" which is valid and reliable because it is not widespread. In Turkey, in some researches, we can see "scales of attitude towards physics/ physics course" adapted from other scales which were developed by another course or subject or by combining items of many other scales. In the literature we recognize that the informations about the details of scales are not articulated in many studies, instead well-known scales related to subject searched are preferred for quick use (Kurnaz & Yiğit, 2010, p. 35).

RATIONALE

The purpose of this study was to develop Likert type scale for measuring attitudes towards physics course while examining construct validity and testing the fit between independence model and the hypothesized model through confirmatory factor analysis (CFA) after performing exploratory factory analysis (EFA).

METHODS

Data were collected from seven high schools in Edirne in Spring of 2006-2007 academic year. The SATPC was administered 865 students (492 girls, 373 males). Students' age range changes between 14 and 18 (M=15.78, SD =.82). Authors of the current study aimed to develop three different scales for biology, chemistry, and physics courses. Although each study was conducted in parallel way, authors developed three different scales using different samples. In the current study, researchers examined literature to identify variables which was included by attitude. Then researchers wanted 20 high school students in tenth grade write a composition about their feelings and thoughts on physics course in March 2005. Content analysis was performed for these compositions. In terms of literature and content analysis, researchers produced 46-item for SATPC. After re-examining process, number of items was reduced 23 because some items could be confusing.

EFA, Cronbach α, Pearson correlation and independent sample t-test were performed in SPSS 17 for Windows. CFA was performed in AMOS 16.0. "Maksimum likelihood (ML)" method was used for both EFA and CFA (Tabachnick & Fidell, 1996, s.665; Brown, 2006, s. 49).

RESULTS

The EFA (with ML and direct oblimin rotation with delta set at 0) was conducted. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .968, which suggested that data were appropriate for factor analysis. In addition, Bartlett's test of sphericity was found to be statistically significant, $\chi^2(231)=12072.794$ $p<.05$. This finding also indicated that the sample was suitable for factor analysis.

While deciding on the number of factors, the eigenvalues greater than one and the scree plot were used as criteria. In additon .32 was used as a critical value to examine factor pattern loadings (Tabachnick & Fidell, 1996). According to result of first EFA, although the eigenvalue was greater than one suggested remaining three factors, scree plot and factor matrix yielded one-factor model. The item 8 was removed because it didn't take place in first factor and the EFA was again conducted. As a result of second EFA, SATPC revealed one-factor and this factor explained 49.56% of total variance.

CFA was performed to test a one-factor model of the SATPC (see Figure 1). While evaluating goodness of fit, RMSEA (the Root Mean Square Error of Approximation), TLI (Tucker-Lewis Index) and CFI (Comparative Fit Index) were used as critical values. (Tabachnick & Fidell, 1996; Brown, 2006; Weston & Gore, 2006). Results demonstrated a satisfactory fit for model (RMSEA=.075 TLI=.892 CFI=.911). According to Browne and Cudeck (1993) values of RMSEA between .05 and .08 indicate modarate fit. Accoding to Brown (2006), TLI and CFI values should be 0.90 and higher. The standardized regression coefficients of the one-factor SATPC changed from .43 to .88 and all of these coefficients were statistically significant.

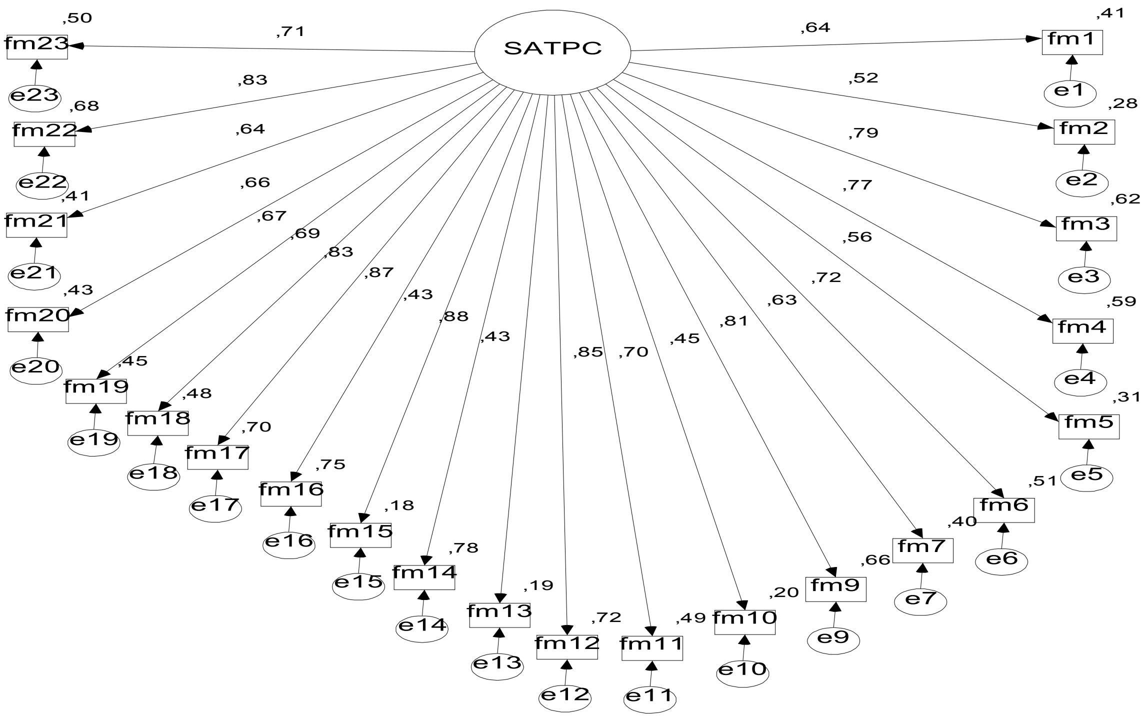

Figure 1. CFA of SATPC

The correlations of items consisting of the whole total scale were calculated in order to determine whether each item included in the scale is related to the concept which was wanted to worked out. Afterwards, in order to determine to what extend adequateness of each item included in the scale in distinguishing the individuals in terms of the feature which they evaluate for the meaningfulness of difference between item points of the top 27% and the bottom %27 groups which was determined by total point, t-test was used.

Tablo 1. t test for %27 low and high groups and item total correlation

Item	t (%27 low and high groups)	Item-Total Correlation	Item	t (%27 low and high groups)	Item-Total Correlation
fm1	22.40*	.62**	fm13	13.78	.44**
fm2	15.76*	.53**	fm14	38.09	.86**
fm3	29.46*	.78**	fm15	12.34	.45**
fm4	28.84*	.74**	fm16	38.02	.84**
fm5	18.28*	.57**	fm17	37.12	.81**
fm6	22.84*	.71**	fm18	29.81	.68**
fm7	21.84*	.61**	fm19	23.47	.66**
fm9	34.82*	.80**	fm20	21.65	.65**
fm10	13.14*	.46**	fm21	18.44	.61**
fm11	22.54*	.69**	fm22	33.80	.81**
fm12	36.40*	.82**	fm23	24.94	.70**

*p<.05 (t test), **p<.05 (correlations)

According to the Table 1, item total correlation is meaningful and it changes between .44 and .86. In addition to this, it can be considered that the items have discrimination power according to t test results.

Furthermore, whether there is difference among attitude points of the students or not is tested according to willingness of the students towards physics subjects. It was seen that attitude points of the students having high level willingness towards physics course ($\overline{X}_{high}$=79.357) are significantly higher than the students having low level willingness ($\overline{X}_{low}$=53.733) [$t_{(815)}$=23.38, p<.05]. This finding suggested that the discrimination power of the scale exists.

The Cronbach alpha coefficient was .95. The scale was administered to the same group (n=105) two times in four weeks interval to determine the test-retest reliability of the scale. Correlation coefficient was found as .76 (p<.05).

CONCLUSIONS AND IMPLICATIONS

The purpose of the current study was to develop SATPC. According to EFA, the scale consists of one-factor, and this structure was validated by CFA. In additon, it is known that there is a relation between the construct validity and internal consistency. The Cronbach alpha coefficient was high and deemed acceptable. Further validation with different populations and cultures would also warrant increasing external validity.

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SECOND LEVEL IRISH PUPILS' AND TEACHERS' VIEW OF DIFFICULTIES IN ORGANIC CHEMISTRY

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Abstract: Chemistry has been identified as a difficult subject by many and a decrease in the numbers studying Chemistry has been found in many countries (Reid, 2008). Childs & Sheehan (2009) have identified the Organic component of Chemistry as a problem area at second and third level in Ireland. This investigation was conducted as part of a research study looking at the difficulties of Organic Chemistry for second and third level students in Ireland. Chemistry Teacher Questionnaires were distributed to 73 participating schools and Second Level Pupil Questionnaires were distributed to 35 participating schools in Ireland. The Chemistry Teacher Questionnaire investigated the teachers' perceptions of teaching Organic Chemistry. The Second Level Pupil Questionnaire sought background contained a Diagnostic Test assessing nine core Organic Chemistry topics. The average score on the Diagnostic Test was 53 %. The main areas of difficulty identified by teachers and pupils in this study were: Structural Formulae, Functional Groups, Characteristics of Organic Compounds, Organic Reactions (types and mechanisms) and Laboratory Work.

Keywords: Organic Chemistry, chemical misconceptions; conceptual understanding

BACKGROUND

Many researchers have recognised a mismatch between the enthusiasm of Chemistry lecturers and teachers and their students' interest levels (Johnstone 1991, Johnstone 2010, Johnstone and El-Banna 1986, Millar 1991). Johnstone (2010) has recognised a snowball effect of recurring misconceptions in Chemistry education at second and third level over the past 40 years. Too much attention has been given to the 'chemical', and not enough attention given to the 'education' part of 'Chemical Education' (Ellis 1994, Mahaffy 2005). Many people have highlighted the gap in communication between those who carry out Chemical Education Research (CER) and those who teach Chemistry (Ellis 1994; Childs 2009). In addition many research studies involve sample groups of high-ability learners, so the findings may not be generally applicable. Many revised curricula and associated textbooks are still failing to understand how young people learn.

> "*We have been busy changing the menu in the ship's restaurant while the ship had been sinking"* (Johnstone 2010, p.22)

Rather than developing new curricula and programmes for teaching Chemistry, it is more important for chemical educators to first understand the processes of learning. Johnstone listed nine areas of Chemistry that were established as difficult in 1971. Many of these same topics were again identified as difficult by Ratcliffe (2002), Jimoh (2005), Johnstone (2006) and in Ireland by Childs and Sheehan (2009). These studies indicate that there is a persistent problem with how Chemistry is being taught and highlights the urgent need for change. Much of the CER focus seems to be on the "classic core" Chemistry topics of the mole concept, the particulate nature of matter, equilibrium, and chemical calculations. While extensive reseach has also been carried out in investigating learners' difficulties with Organic Chemistry very little has been done in this area in Ireland.

REVIEW OF LITERATURE

Organic Chemistry is an essential part of everyday life; it has enormous economic significance, particularly in Ireland with its sizable pharmaceutical industry and is major part of the Irish Chemistry syllabus. However, for those learning Organic Chemistry for the first time, it can

cause confusion and difficulty. There are three main difficulties in Organic Chemistry (Ellis 1994): there are no problem-solving algorithms; it requires three-dimensional thinking; and it has an extensive new vocabulary. As a subject it has a difficult reputation, as students do not see its vitality and relevance in the typical second level or third level course.
"*Among students, the organic chemistry course has a bad reputation of mythic proportions. From their viewpoint organic chemistry is a dreaded 'wash-out' course*"

(Katz, 1996, p.440)

The abstract concepts of Chemistry require thinking on several levels, and Organic Chemistry is no exception to this. Johnstone (1991) described the multi-level thought needed in Chemistry in his 'Triangle of Chemistry'. The learner is faced with three levels of thought: the macroscopic, submicroscopic and symbolic. The 'Macroscopic' level refers to what is tangible and visible e.g. a salt dissolving in water. The 'Sub-microscopic' level refers to what is molecular and invisible e.g. the sodium and chloride ions and water molecules. The 'Symbolic' refers to the chemical symbols and equations to represent the ions and atoms and molecules etc. e.g. $Na^{+}_{(aq)}$ and $Cl^{-}_{(aq)}$. While an expert may be able to move easily between these levels, the combination of just any two levels, or even the comprehension of the non-macroscopic levels, can be demanding for a beginner. Much research (Johnstone 1981, Childs and Sheehan 2009, Ratcliffe 2002, Johnstone 2006) over the past 40 years, has found Organic Chemistry to be one of the main areas of difficulty for pupils at second level.

Piaget's model of Cognitive Development suggests that the cognitive ability and development of the learner is age-dependent. Reaching the formal operational stage of development at 11 years, as Piaget first suggested, should mean that these learners can then handle abstract ideas and think logically. More recent research has shown Piaget's ages to be too optimistic. Work carried out by Shayer and Adey (1981) in the UK and again in 2007 (Shayer et al. 2007) showed that the percentage of pupils at age 16 reaching the formal operational level was much lower than previously thought. This work has been repeated recently on Irish pupils and students, and showed that less than 20% of pupils at senior cycle in second level and less than 40% of students at third level were operating at the highest level (Childs and Sheehan 2010). If these findings are generally true, it would have important educational implications, at second and third level.

The Irish second level educational system consists of a three-year junior cycle and a two-year senior cycle course. The senior cycle culminates with the Leaving Certificate (LC) examinations, which determine entry to third level education. The LC Chemistry course at is a two year course and is offered at Higher Level (HL) or at Ordinary Level (OL). The average age of the pupils beginning the Senior cycle is 16 and the recent work of Childs and Sheehan (2011) show that the percentage of Irish pupils operating at the formal operational level is actually lower than in the U.K. This means that most of these pupils start the LC Chemistry course without the ability to think in an abstract and conceptual manner. In teaching Chemistry, it is critical that educators are aware of the cognitive level and ability of their learners, who otherwise will become swamped by the multi-level cognitive demands of Chemistry (Johnstone 1991) as well as the other scientific and mathematical demands of the subject. Shayer and Adey (1981) devised a Curriculum Analysis Taxonomy (CAT) based on Piaget's work to classify curriculum objectives. This analysis found that pupils need to be at the formal stage of cognitive development in order to learn and understand core Organic Chemistry ideas. The same basic topics are common to all introductory Organic courses, including the LC Chemistry course. If the majority of second level pupils in Ireland have not yet reached the formal stage of cognitive development, it is not surprising that many topics are difficult for them, as was found by Childs and Sheehan (2009). When learners lack the cognitive ability necessary to learn and understand the topics encountered on their courses, alternative approaches may be adopted e.g. rote learning.

Organic Chemistry is a significant part of the Irish LC Chemistry syllabus (~ 20%) and the examination (~25%). The Chief Examiner's Reports (S.E.C. 2008) have recognised a tendency for Leaving Certificate candidates to avoid Organic Chemistry, even though this severely restricts their choice on the examination paper. This indicates a tendency by pupils or by their teachers to avoid a topic that they consider difficult.

The identification of Organic Chemistry as a problem area in Chemistry in Ireland and elsewhere provides the rationale for this work. The research questions aim to investigate more deeply what Irish second level pupils find difficult about Organic Chemistry and why.

- What specific areas of Organic Chemistry do Irish second level pupils find difficult?
- What specific areas of Organic Chemistry do second level teachers in Ireland find most difficult to teach?
- What are the causes for these areas of difficulty in Organic Chemistry?
- What teaching approaches contribute to the effective teaching and learning of Organic Chemistry?

METHODOLOGY

The Second Level Pupil Questionnaire (10 pages) took ~30 minutes to complete and contained two sections: Section A in the Second Level Pupil Questionnaire collected personal information from the participants and their previous Mathematics and Science experiences; Section B was a Diagnostic Test, with nine questions, each assessing a different Core Organic Chemistry topic from the LC Chemistry course. The test was designed to be answered after pupils had completed the Organic Chemistry section of the syllabus and assess the pupils' level of knowledge and understanding.. While some of the questions in the Diagnostic Test were designed by the author, some were also adapted from previous studies (Boa and Eames 2006, Brookes and Scott 1979, Reid 2003, Taagepera and Noori 2000).
The Chemistry Teacher Questionnaire was just two pages and took 10 minutes to complete; it had just one section and aimed to find out the teachers' perspective and approach to teaching Organic Chemistry, as well as their views of their pupils' perceptions.
Ethics approval was sought and granted from the University of Limerick Board of Ethics. Both questionnaires were piloted. A random sample of 100 schools was chosen for the study in April 2010, representative in school type and gender of the 546 schools teaching LC Chemistry in Ireland. In total 73 schools returned questionnaires: 35 (48%) of the schools had pupils and teachers who participated, while in the other 38 (52%) of the schools only the teachers participated. This resulted in a sample of 276 pupils and 79 teachers.
The questions and responses in each questionnaire (except for the free responses) were coded accordingly and inputted into SPSS Version 16.0. The data was first examined to view frequencies of responses; cross tabulations were then used to investigate what factors contributed to the participants' attitudes to and understanding of Organic Chemistry.

RESULTS

Second Level Pupil Questionnaire

258 (93.5%) of the pupils involved in this study were in sixth year and the remainder in fifth year Leaving Certificate Chemistry. 246 (89.1%) of the pupils were studying HL LC Chemistry. 165 (59.8%) found Organic Chemistry difficult. However, 158 (57.2%) enjoyed studying it and 124 (44.9%) agreed that it was interesting. 94 (34%) found it easy to learn: the main reason given by 41 (44%) of these pupils was that Organic Chemistry is logical and can be learned systematically. Many of these pupils also found the subject interesting and relevant to their own lives. In comparison, a greater number of pupils (165, 59.7%) found Organic

Chemistry difficult to learn. The most common reason for 52 (31.5%) for finding Organic Chemistry difficult to learn was the length and detail of the course.

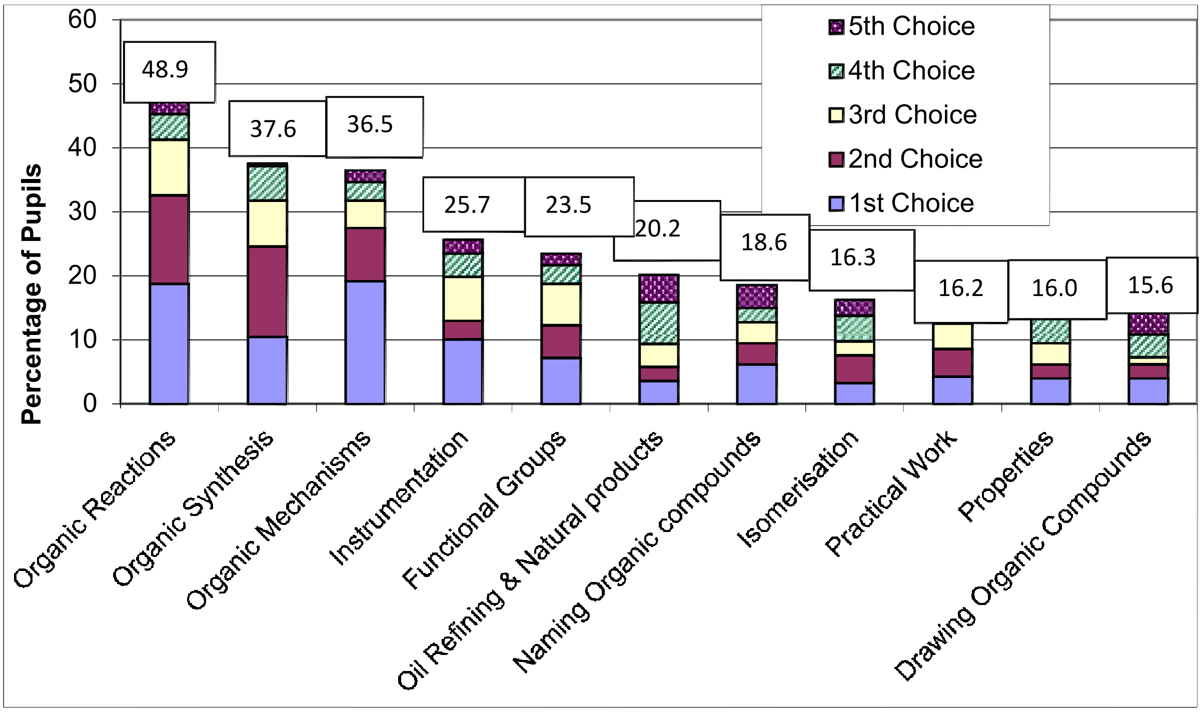

Figure 1. Top five most difficult Organic Chemistry topics as rated by second level pupils (n=276).

Difficult topics listed by pupils were: differentiating the functional groups, naming and drawing compounds; organic formulae; and reactions and mechanisms. It can be seen from Figure 1 that Organic Reactions, Synthesis, Mechanisms, Instrumentation and Functional groups were listed as the top five most difficult topics. Organic Mechanisms was listed as the number one most difficult topic by the highest number of pupils (53, 19.2%). However, Organic Reactions had the highest aggregate score as it was listed as difficult by 135 (48.9%) of the pupils.

The average number of questions attempted by each pupil was seven (out of nine). Taking the standard pass rate of 40%, 98 (35.5%) of the pupils failed the Diagnostic Test and 178 (64.5%) passed. The average score for the pupils involved in this study was 52.6%.
There was a difference of 5% between the male (49.4%) and female (54.3%) average scores, but this was not significant (p=0.161). Pupils studying Higher Level Chemistry scored an average of 36% more than those studying Ordinary Level. Also pupils who were studying HL Mathematics for their LC scored an average of 28% more than those studying OL. Pupils who had studied HL Junior Certificate Science scored an average of 36% more than those that studied OL. These differences were significant. Pupils who received higher grades in their HL Junior Certificate Science also attained higher scores in the Diagnostic Test.
Table 1 that follows shows a summary of the percentage of pupils who attempted each of the questions as well as the average score of each. Pupil perceptions of topics in Section A were consistent with their performance in the Diagnostic Test in Part B, with the exception of Naming Organic Compounds. This topic was poorly answered in the Diagnostic Tests despite being perceived as easy by pupils. Question 7 on Reaction Mechanisms was attempted by the least number of pupils and was the most poorly answered question in the test.

Question	Topic	Attempt (%)	No Attempt (%)	Average score (%)	Mark Order
1	**Drawing**	94.6	5.4	77	1
2	**Naming**	90.6	9.4	45	8
3	**Isomerisation**	84.1	15.9	66	2
4	**Electrophilic attack**	76.8	23.2	51	5
5	**Reaction Types**	81.2	18.8	46	7
6	**Reaction Synthesis**	66.3	33.7	47	6
7	**Reaction Mechanism**	51.1	48.9	29	9
8	**Classification**	77.2	22.8	56	3
9	**Properties**	72.8	27.2	55	4

Table 1. Summary of the pupils' performance in the individual questions. (n=276)

Chemistry Teacher Questionnaire

Most of the teachers agreed that Organic Chemistry is interesting and enjoyable to teach. Of the 67 teachers, 42 (63%) said it was easy to teach with 25 (38%) finding Organic Chemistry difficult to teach. The main reasons given by teachers who found Organic Chemistry easy to teach was that it is a logical topic (22, 54%) and also interesting and relevant to everyday life (16, 39%). The main reason given by the teachers who found it difficult to teach was the large amount of information to be taught in the syllabus (17, 68%). Even though the teachers felt that the pupils found Organic Chemistry interesting, they also acknowledged that the pupils don't find it easy to learn. 70 (87%) of the teachers answered the question about their pupils' perspective of learning Organic Chemistry: 53 (76%) of these teachers felt that their pupils find Organic Chemistry difficult to learn mainly due to the overload of information (27, 51%), and also the difficulty of distinguishing the functional groups (10, 19%). 16 (21%) of the teachers felt their pupils find Organic Chemistry easy to learn because of the logical nature of the organic families (12, 75%).
73 of the 79 teachers answered an open-ended question identifying the most difficult topics to teach. Instrumentation was listed as the most difficult topic to teach by 42 (58%) of the teachers. Reasons given by these teachers were the amount of information for the pupils to memorise, as well as difficulties in distinguishing between the principles and processes of the different techniques. 31 (74%) of these teachers associated the difficulty of teaching Instrumentation with the fact that many of them, as well as their pupils, had never used or even seen the instruments. The vague syllabus description of the topic also made Instrumentation difficult to teach. The second overall most difficult topic to teach was Organic Mechanisms (40, 55% of the teachers). The main reasons given by teachers for this were the difficulty of the concepts and the difficulty the pupils have in visualising the steps of the mechanisms. Mechanisms, Synthesis and Reactions are difficult to teach, as are Reaction Schemes, as they all rely on the pupils' understanding of functional groups and their characteristics. Many teachers have recognised the high cognitive demand of Organic Reactions, Mechanisms and Synthesis: these topics integrate all that the pupils have learned in Organic Chemistry. Many of the teachers recognised that their pupils' attempt to 'learn off' reactions and mechanisms because they have no understanding of the functional groups and transfer of electrons etc., and they cannot comprehend the abstract concept.

In the Second Level Pupil Questionnaire and Chemistry Teacher Questionnaire, common topics were identified as easy to teach and learn by pupils and teachers. While Classification and Isomerism were identified as 'easy to teach' by the teachers, they were not included as 'easy to learn' topics by the pupils. Isomerism and Classification were the second and third highest scoring questions in the Diagnostic Test, indicating the pupils' understood these topics even though they were not identified as 'easy to learn'.

Difficult topics	Chemistry Teachers' own Rating. (n=79)	Chemistry teachers' perspective of Pupils' Rating. (n=79)	Chemistry teachers' perspective of Pupils' Rating. (n=35)	Second Level Pupils' own Rating. (n=276)
Organic Mechanisms	2nd	1st	1st	3rd
Organic Reactions	3rd	4th	4th	1st
Organic Synthesis	4th	3rd	2nd	2nd
Instrumentation	1st	2nd	3rd	4th
Functional Groups	Not in top 5	Not in top 5	Not in top 5	5th
Isomerisation	Not in top 5	5th	5th	Not in top 5
Natural Products	5th	Not in top 5	Not in top 5	Not in top 5

Table 2. Top five most difficult topics as rated by Second Level Chemistry Teachers and pupils.

In Table 2, it can be seen that both teachers and pupils chose the same four out of their top five most difficult Organic topics, though not in the same order. The teachers' perspective are listed in two columns; one to represent all teachers involved in the study (n=79) and the other to represent the teachers teaching the 276 pupils involved in the study (n=35).

CONCLUSIONS

Johnstone (2000) recognised that what may be logical and simple to the Chemistry teacher, may not be so for the learner. To teach for understanding, teachers need to have an accurate awareness of their pupils' prior knowledge, misconceptions and level of cognitive development. If teachers have a better understanding of their pupils' opinions and attitudes, they may be better able to adapt their lessons to facilitate a deeper and more holistic understanding of the subject. The Chemistry teachers made a relatively accurate prediction of their pupils' attitudes towards Organic Chemistry in the Leaving Certificate. However, the teachers assumed their pupils held a more negative view of learning Organic Chemistry than they actually did. It is important for teachers to be familiar with their pupils' attitudes and approach to learning as well as their level of cognitive development and prior knowledge (Johnstone 2010). It is clear from this research that the topics listed in Table 3 are among the main topics that need addressing in designing new teaching materials. Other topics to be addressed include structural formulae, functional groups, characteristics of organic compounds and laboratory work.

The findings from this research have been used to design appropriate teaching materials to facilitate the teaching and learning of Leaving Certificate Organic Chemistry, in order to make it more interesting and accessible to pupils. Through trialling and evaluation of these materials (Sept-Dec 2011), this project will integrate the research and practice of Chemical Education and thus improve the teaching and learning of Organic Chemistry in Irish schools.

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EXPERIMENTAL COMPETENCIES IN SCIENCE: A COMPARISON OF ASSESSMENT TOOLS

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Abstract: Standards and models of science competencies refer to experimenting as an essential part of science education. Thus, valid assessment tools for experimental skills are necessary. Usually, written tests are used to measure these abilities. However, written tests exclude important process-aspects of experimenting (e.g. setting up the apparatus). The issue of validity arises. On the other hand, tasks with hands-on experiments are complex and resource-consuming. Assessment tools for measuring experimental skills in a process approach that are also applicable in large-scale assessments are desirable. The main goal of our project is to develop and to validate such tools. The development is based on a model of experimental competencies that focuses on process issues (e.g. assembling the experimental setup). Each student carries out one experimental task with a hands-on experiment and another task either with a computer-based simulation-workbench or with a computer-based written test. We regard tests with hands-on experiments as the benchmark for other forms of assessment. However, the other two methods are much easier to apply in large-scale assessments. We assume that for assessing experimental skills a simulation-workbench is closer to a hands-on experiment and thus more valid than a written test. To test this hypothesis, we examined correlations between students' scores in various subscales of experimenting gained by the three approaches.

Keywords: Experimental competency, assessment, hands-on experiment, computer simulation

FOCUS OF THE STUDY

Standards and models of science competencies refer to experimenting as an essential part of science education. Thus, valid assessment tools for experimental competencies are necessary. Usually, written tests are used to measure these abilities. Tasks with hands-on experiments are often avoided, because they are complex and resource-consuming. Written tests exclude important process-aspects of experimenting (e.g. setting up the apparatus). The issue of validity arises. Assessment tools for measuring experimental competencies in a process approach that are also applicable in large-scale assessments are desirable. The main goal of our project is to develop and to validate such tools. The development is based on a theoretical model of experimental competencies.

BACKGROUND AND FRAMEWORK

There are two established methods to assess experimental competencies: tests with hands-on experiments and written tests. Tests with hands-on experiments can be analysed with regard to the achieved experimental outcomes (Harmon et al., 1997; Adamia et al, 2008) or with regard to the process of experimenting (e.g. Neumann, 2004). Most large-scale assessments apply written tests, predominantly with multiple-choice-questions. Baxter and Shavelson (1994) examined the exchangeability of written tests and hands-on experiments. They additionally employed a computer simulation as a third test method. Shavelson et al. (1999) reanalysed the data of 1994. They compared three scores, which each test person achieved with (a) a computer simulation, (b) a written test and (c) a hands-on experiment. Only the results of the experiments were rated, not the experimental processes. The hands-on experiment was taken as the benchmark (direct observation and expert rating). The highest correlation existed between the benchmark and the analysis of the log sheets students produced during the hands-on experiment (r = 0.78). The least correlation was found between the benchmark and the written tests (r = 0.46). Shavelson et al. explain this low correlation with the missing direct feedback given by a written test. The correlation between the benchmark and the computer simulation was unexpectedly low, too (r = 0.50). Assessment is based on models of experimental competencies, e.g. by Klahr (2000), Hammann (2004) and Lunetta (2003). All these models describe three phases of experimenting: hypotheses, performance and analysis. Our model (Fig. 1) is based on these established models and focuses on the performance phase. The model does not imply a strict sequence of steps. The components can be passed in an iterative and not always complete sequence.

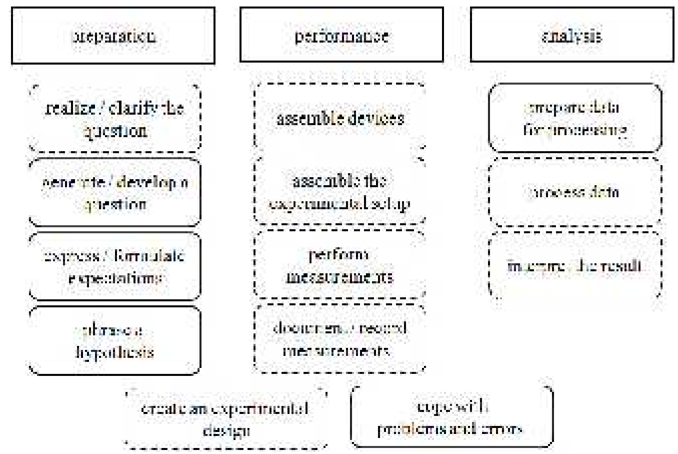

Fig. 1 model of experimental competence

RATIONALE AND METHODS OF THE STUDY

In this study we compare three different assessment tools for experimental competencies. They are based on hands-on experiments, written tests and computer-based simulation-workbenches. Each test person works in at least two different test environments. One of them is a hands-on experiment. Like Shavelson et al. (1999) we take the hands-on experiment as the benchmark for the comparison. In contrast to Shavelson et al. we analyse the students' *processes* of experimenting.

RESEARCH QUESTIONS AND HYPOTHESES

For each student we have at least two scores describing his or her experimental competencies on the basis of different assessment tools. Our main hypotheses refer to the correlations between these sets of scores:

H1: Written tests are insufficient predictors for hands-on tests ($r < 0.7$). This hypothesis directly follows from the results of Shavelson et al. (1999), who found a low correlation even though the authors only rated the experimental *outcomes*, without taking *processes* into account.

H2: Computer simulation workbenches are sufficient predictors for hands-on tests ($r > 0.7$). At first glance, the results of Shavelson et al. (1999) contradict this hypothesis. We expect a higher correlation, because we take into account the *processes* in both test formats and use technically more sophisticated simulations, which are very close to the actions in the hands-on experiments.

A further research question concerns the analysis of tests with the simulation-workbench:
Are ratings solely based on log-data that are generated by the simulation software as valid as ratings based on the video-analysis of screen recordings? A positive answer would facilitate large-scale assessments with this tool.

TASKS AND METHODS OF DATA COLLECTION

We developed three experimental tasks for the domain of electricity in secondary school curricula (e.g. to determine the voltage-current-characteristics of a bulb). In the hands-on experiments students have a set of scientific apparatus (more than the experiment affords) and a structured work sheet at their disposal. Students' actions are videotaped and the work sheets are collected. The simulation workbench imitates the hands-on experimental situation in a semi-realistic way. The work sheet is filled-in online. Data are collected by screen-recording and log-data recording (see research question). In the written version the test persons follow two fictitious students who work on an experiment. The test persons make decisions, what these students should do to solve the experimental task. The test contains multiple choice questions and open questions. It is presented online. In order to exclude consecutive faults, partial solutions are presented in the written test before a new sub-task is posed.

DESIGN OF THE MAIN STUDY

For the main study two tasks are implemented in the three assessment tools described above (hands-on experiment, written test, computer simulation). Figure 2 shows the design of the main study. In a pre-test, selected cognitive parameters were gained of 180 students (grades 10 to 12, upper secondary schools) by means of a questionnaire: content knowledge concerning electricity, general intelligence and spatial intelligence. Based on these data, four groups (matched samples) with about 35 students were put together. The students took part in a training-session, in which they were introduced to the apparatus of the tests, the handling of the simulation-workbench, and the handling of the written online-test. After the training-session they performed the actual tests as described in Figure 2. The design makes sure that each student performs one test with the hands-on experiment that we take as the benchmark for this study.

Classroom	Pre-test (selected cognitive parameters)			
Science Education Lab	Training (apparatus and software)			
	Tests of experimental skills			
	Group 1	Group 2	Group 3	Group 4
University of Bremen	R1	S1	R1	W1
	S2	R2	W2	R2

R: hands-on experiment, W: written test, S: simulation workbench

Fig. 2 design of the main study

DATA ANALYSIS

The methods for analysing students' performances were developed and validated in two comprehensive pilot studies with about 75 students. The piloting also tested the experimental tasks. First of all, a set of categories was developed with regard to the components of experimental competence (see Figure 1). The focus lay on students' actions while they carried out the hands-on-experiments or the experiments with the simulation-workbench. The category-based analysis showed that eight components of the theoretical model can be identified and separated in our test settings (see dashed boxes in Figure 1). Students' actions in these components can be encoded with a high inter-coder-reliability (Cohen's Kappa = 0.84).

The content validity of the category-based analysis was confirmed by interview studies. Eleven students carried out one of the tasks with a hands-on experiment or with the simulation-workbench. Stimulated recall interviews were conducted with the students directly after the tests. The qualities of students' actions were first coded by the category-based approach (data: videos or screen-recordings). During this first coding the rater did not yet know the interview data. Afterwards the same rater included the interview data for rating students' actions. The comparison of the two results shows a high content validity of the category-based-analysis.

The analysis of the *sequences* of actions gained from the hands-on and the multimedia settings yields that the sequences alone are not sufficient to rank students' experimental performance (e.g. for measurement). There are no simple surface action patterns indicating good or bad experimental performance. Hence, the *quality* of the actions has to be taken into account. The flow chart in Figure 3 exemplifies the coding scheme for the setup-phase. It illustrates how the coding decisions are made and how they lead to a quality index on an ordinal scale with five ranks. This *sequence analysis* leads to quality parameters for each student in each investigated model component and for each assessment tool. The reliability of this coding is high (e.g. Cohen's Kappa = 0.91 for the setup-phase). To validate this method, the assessments were compared with the results of a high inferent expert rating of the students' experimental competencies (Dickmann, 2011). The results show a high agreement (> 88%).

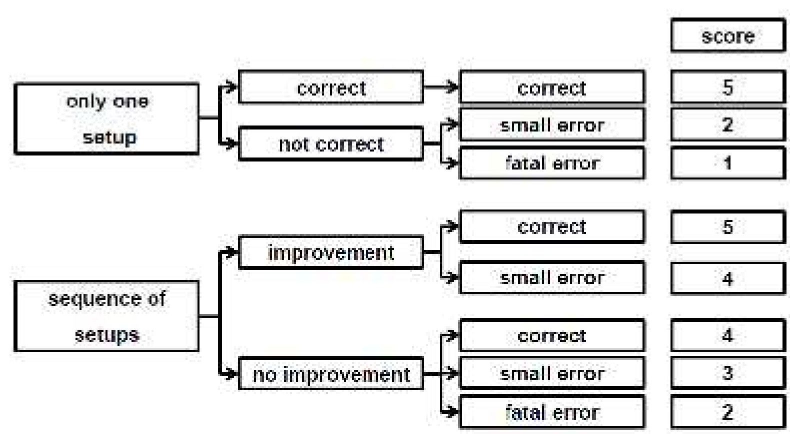

Fig. 3 flow chart for the assessment of students' achievements in the setup-phase

We also developed an algorithm that uses the log-data from the simulation workbench to encode the actions and sequences of actions automatically. Coding decisions according to Figure 3 (e.g. correct/not correct) still have to be made by human raters. But the semi-automatic analysis is less time-consuming and does not reduce the reliability of the final scores (Cohen's Kappa > 0.77).

RESULTS

To test hypothesis 1, correlations between students' achievements in the hands-on tests and in the written tests were calculated. There are significant correlations between the assessment from the written test and the assessment from the hands-on test, but they are very low (Kendall-Tau-b 0.35< 0.47) for all the model components.

To test hypothesis 2, correlations between students' achievements in the hands-on tests and in the tests with the simulation workbench were calculated. Again, all the significant correlations between the assessment from the hands-on test and the test with the simulation workbench are low (Kendall-Tau-b 0.28 < 0.55).

A qualitative analysis of the distributions of students' achievements shows a possible reason for the low correlations. The distributions show on the one hand a ground effect (too many students fail) and on the other hand dramatic changes in students' achievements from one task or assessment tool to the other. Figure 4 illustrates these findings for group 1 and the setup-phase.

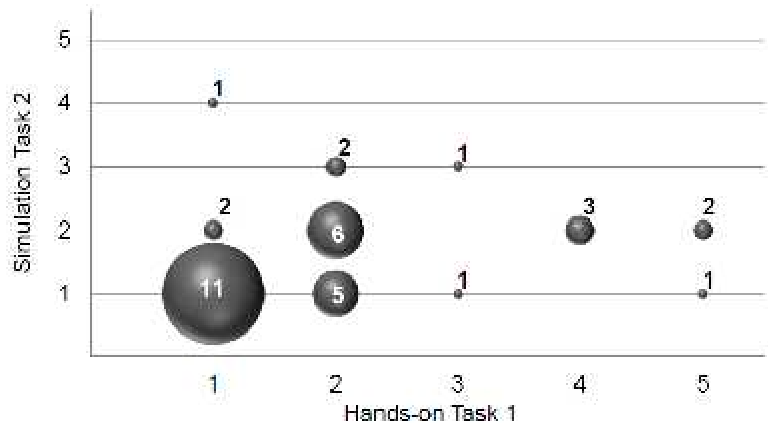

Fig. 4 bubble diagram of the scores for the setup phase for group 1 (Kendall-Tau-b: 0.337*)

DISCUSSION AND CONCLUSIONS

In this study applicable assessment tools for experimental competencies were developed as alternatives to hands-on testing. We also worked out reliable methods for a process oriented data analysis. For the simulation workbench test, an algorithm is available that automatically encodes the students' experimental actions with high reliability.

However, according to the present results, neither the written test nor the test with the simulation workbench is a valid substitute for the process-oriented diagnosis of experimental competencies in hands-on experiments. The observed ground effects in students' achievements show that the specific experimental tasks we used were too difficult for the majority of the students, although we had secured the curricular validity of the tasks and had had positive feedback from teachers, who expected their students to solve the tasks. The ground effects make the interpretation of correlations between the three test formats difficult.

On the other hand, the tests with the simulation workbench turned out to be practicable with regard to an implementation in large-scale assessments (together with the semi-automatic process oriented analysis). Compared to the hands-on tests, the qualitative analysis of students' actions shows very similar patterns of successful experimenting in students' actions and very similar mistakes. Obviously, the challenges and difficulties occurring during the experimental process are not caused by the assessment formats, but by the physics content. Further investigations with experimental tasks that produce a more balanced distribution of students' achievements are necessary to check our present findings. We keep the idea that simulation workbench tests are closer to hands-on tests than written tests.

Two questions arise from this study that have to be answered by further research:

Why are the correlations between students' achievements in the hands-on tests and the tests with computer simulations so much lower than expected?

Why do the students' achievements change dramatically from one task or assessment tool to the other?

One possible reason could be that the two experimental tasks – one posed in the hands-on setting and the other in the simulation environments – differ in their demands and difficulties. This assumption is not confirmed by our data. The distributions of students' achievements are similar when we look at group-accumulated data. The differences in achievements only occur when we compare achievements on the basis of the individual students.

Two possible reasons for our findings challenging the construct "experimental competence" are that (a) experimental competence is no coherent and stable trait behind students' performances or that (b) experimental competence is closely bound to the specific physics content of a task. Schecker (in press) argues in this direction. Whereas the first assumption puts the entire diagnostics of experimental competencies into question, the second assumption can be empirically investigated using a variety of experimental tasks from different content areas. Indeed, there are some investigations that support this idea of content dependency (e.g. Gott and Duggan, 2002). This leads to the question how many tasks from different content areas are necessary for a reliabel diagnostics of experimental competencies.

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A LONGITUDINAL STUDY ON INTERESTS IN SCIENCE

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Abstract: This article will introduce the concept and evaluation of an informal educational program aiming at arousing and furthering children's interests in science and improving their scientific competences regarding scientific literacy (Streller 2009).

The theoretical basis of our course design is the Educational-psychological Theory of Interest (Krapp 2002) and the Self-determination Theory of Motivation (Ryan, Deci 2000).
Since 2004, the learning opportunities have been offered to the children - independently from school and classes – in their free time on a weekly basis over a period of 2 years.
We have investigated the effect of the realization of this concept in longitudinal studies with control group design (N=382). In our investigation we used questionnaires - esp. the Motivational Learning Environment Questionnaire (Bolte 2006) - with several variables to get an insight into the development of interest and intrinsic motivation regarding science learning.
The findings show that the participation in these courses had a positive influence on the children´s interests in science and in learning science.
By evaluating our educational courses we are able now to provide recommendations for science education in primary schools. Furthermore, the findings show how evidence based links between science learning in school and in informal science learning settings can be created to foster the intrinsic motion of students to learn science and how to enhance students' sustainable interests in science.

Keywords: Motivation and Interest to learn science, informal science learning, longitudinal study, Science Learning Grade 4 to 6

INTRODUCTION

The importance of the natural sciences for general education is undisputed (OECD 1999). The German curricula for day nurseries and for science lessons in grades 5 and 6 both already include the foundations needed for later scientific education in view of scientific literacy. However, it seems that "basic scientific education in primary schools … is still difficult territory" (Marquardt-Mau, 2001, p. 85).

Hence we decided to develop an extracurricular educational program called "KieWi & Co.- Kinder entdecken Wissenschaft" (Children discover Science) with the aim of arousing and furthering children's interests in science and to improve their scientific competences. By developing, testing and evaluating our educational program, we try to provide suggestions and recommendations for science education in primary schools.

RATIONAL - THEORETICAL FRAMEWORK AND CURRENT RESEARCH

The theoretical basis of our course design is the Educational-psychological Theory of Interest (Krapp 2002) and the Self-determination Theory of Motivation (Ryan, Deci 2000). According to the interest theory, interest is conceptualized as a specific relationship between a person and a topic, an object, or an activity, which is characterized by positive emotional experiences and feelings of personal relevance. Interest-triggered actions are self-intentional actions, which can assume the form of short-term “interest” for a particular object (situational interest) or a long-term preoccupation with something (individual interest); leading to a relatively strong personality trait (Renninger 1998). Furthermore, because selecting areas of interest is a result of value judgments, the former become meaningful for the self-concept of a person (Hannover 1998).

The Self-determination Theory of Motivation is an approach to explain the support of interests (Ryan, Deci 2002). Self-determination is assumed to be experienced in environments that meet a person´s basic needs: the need for social relatedness, autonomy and competence.

To induce long-term interest-led actions of children, educational environments should be designed as follows: If it is possible to give the learner the opportunity to satisfy his or her inherent psychological needs for relatedness, autonomy and competence, interest-triggered actions will become more likely (Ryan, Deci 2000). Kunter et al. (2007) examined the effects of well-organized learning environments to support students´ interests in a subject and emphasize the crucial factor being how students experience their learning environment.

Following this theoretical framework, we come to three hypotheses:

Arousing interest in natural sciences can succeed,
- if the children´s suggestions and wishes are picked up in the development and realization of the courses,
- if it is possible to enable the children to have experiences of their own abilities and skills in the course of their dealing with natural sciences and
- if a learning climate is created where the children see themselves as socially integrated.

METHODS

Procedure of the intervention

As our intention is to increase children´s interests in science, one-day or other short term projects are impossible for our purpose because both the development of competencies and of areas of interest to form relatively stable personality traits requires active and repeated efforts on the part of the learner. In this way the 8 to 12 year-old participants take part in weekly courses that follow a systematic pattern and are designed for the long-term. In a period of up to two years they get to know scientific basics and ways of working by investigating age-appropriate problems in small groups. An example is shown in the following.

In the course unit “water”, the children are confronted with an everyday phenomenon (melting an ice cube in a glass of juice) and are asked to observe and describe exactly what they see. After watching the phenomenon the question arises what actually happens with the ice cube´s melt water. The children formulate three different assumptions: The melt water either sinks, collects at the surface, or mixes equally with the juice. Having formulated these ideas, the children independently start planning experiments to test their assumptions. Some children suggest using an ice cube of colored water to be able to follow the melting process in more detail. After carrying out their experiments, the children’s observations are collected and plausible explanations are discussed. At first it seems certain that the cold water sinks to the bottom of the glass; a result that is doubted by some children, however, since the cause for the melt water sinking to the bottom could be the higher density of the dye used. The children are now asked to plan and carry out another experiment to test this hypothesis. A deductive pattern of thought leads to the answer: warm colored water rises to the top in a beaker of cold water. If the dye was more dense than water, it would sink to the bottom of the glass.

This example shows how children can learn scientific ways of thinking on the basis of supposedly “unspectacular everyday phenomena”. The children can obtain a high degree of self-determination, autonomy and competence experience since they are able to follow and discuss their own ideas and do not receive prefabricated experimental procedures they simply have to follow step by step.

Procedure of the longitudinal study

Following the theoretical frame, a longitudinal study (including a control group) was the best way to find out how strong and lasting the resulting effects regarding the furthering of interests might be. We decided to use a questionnaire because of the following reasons:

First, to run a longitudinal study with more than 100 participants effectively, the use of a questionnaire is not as time consuming as interviews. A second advantage compared to interviews is the anonymity. In this way we hope to reduce answers regarding social desirability. To fill out a questionnaire and to agree or disagree to items is not simple for children but simpler than generating free answers (Rost 2004).

Therefore, we adapted a questionnaire and formulated the items in a children-appropriated language. Most of the items used are adopted from other studies (Table 1) and are well tested.

Variables relevant to the study in order of position in the questionnaire	Source of the items	Number of items
● **Socio-demographic data**		
● **Science-related activities during free time**	Hoffmann, Lehrke 1998 (supplemented)	7
● **Preferences concerning topic and**	modified after Bos u.a. 2005 (supplemented)	11
preferences concerning method		10
● **Motivational learning environment***	Bolte 2006	15
Satisfaction (emotional aspect)		
Willingness to participate (value commitment)		
subject relevance (object)		
Comprehensibility (competence)		
group cooperation (relatedness)		
opportunity to participate (autonomy)		
● **Self-concept regarding abilities**	Hoffmann, Bolte 2003	5
● **Attitudes towards natural sciences**	modified after Hoffmann, Bolte 2003	12

Table 1. Variables in the questionnaire; *six subscales, in brackets the relation with the pedagogical interest theory (Krapp 2002) and the self-determination theory (Ryan, Deci 2000)

There are two different versions of the Motivational Learning Environment (MoLE) questionnaire: The REAL version investigates the actual characteristics of the instruction in general and the IDEAL version investigates the desired characteristics (Bolte 2006).

Data sources

114 children in eight different KieWi groups (two groups of each round I-IV; Figure 1) filled out a questionnaire at the beginning of the KieWi course (t0), after each half a year of participating in the course (t1…t4) and half a year later (t5; follow up). 268 children from different schools (control group) were asked, too.

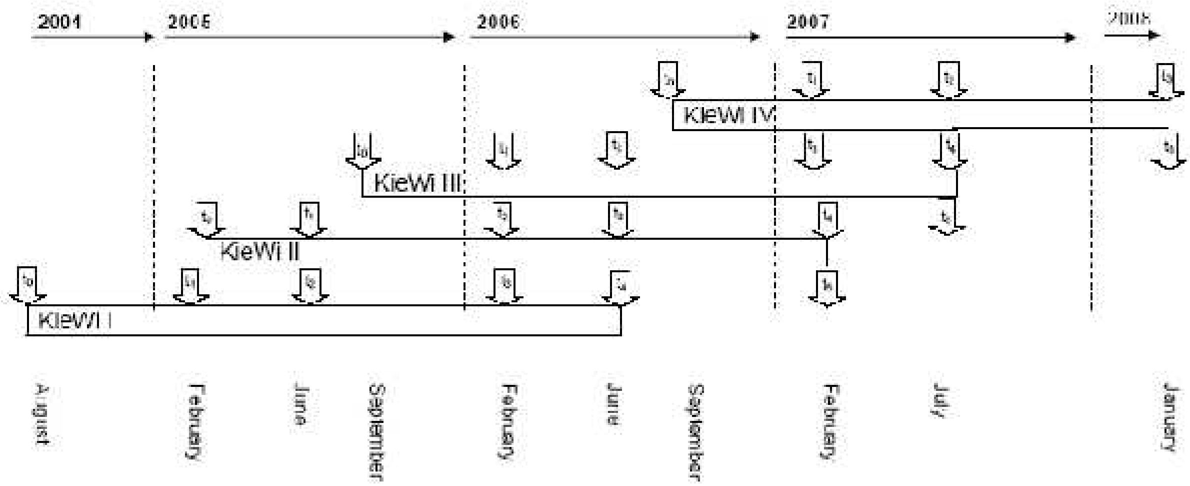

Figure 1. Schedule of the successive courses and times of data collection (arrows)

As may be expected of a longitudinal study, there are some missing data. If we take into our analyses and considerations only those students who took part in all of our data collections, we come to a sample as it is listed in Table 2.

Time of data collection	t_0	t_1	t_2	t_3	t^*_4	t^*_5	Control group
Number of children	114	95	75	64	46	33	268

Table 2. Sampling distribution, adjusted; *KieWi group IV missing cf. Fig. 1

Data analyses and homogeneity analyses

We used nonparametric tests for analyzing the data because of the ordinal measurement scale, the relative small sample and the not normally distributed data.

The sample of the KieWi children is a dependent sub sample, so we used the Wilcoxon test and the Friedman test for the analyses. But compared to the control group, the KieWi children (intervention group) and the control group are independent sub samples. Also independent from each other are the four KieWi groups I-IV. For analyzing these comparisons we used the Mann-Whitney U test and the Kruskal-Wallis test.

To summarize the data of the four different KieWi groups into one (to get a larger basis for the analyses), we calculated all possible pair comparisons to check the homogeneity of the different KieWi sub-groups. From all 351 comparisons we found only 14 significant differences. Because of this result the four KieWi groups are summarized into one for our further analyses.

RESULTS AND FINDINGS

During this study over nearly four years we collected a lot of data. Unfortunately it is not possible to show all of them, so we decided to give an insight into a selection of the findings.

Pupil's assessments of their self concept

The results of the scale self-concept with reference to natural sciences (α=.77) are shown in comparison to the children of the control group, differentiated according to grade (Table 3). In fact, the children who are going to take part in the KieWi course (t_0) and the children at the same age in the control group do not differ significantly in their estimation of their self-concepts of skills, but after one year this effect has increased (between t_1 ./. t_3 (Z = - 2,100 p <0.05) and between t_3 ./. t_5 (Z = - 2,019 p .043)). Regarding the KieWi children, a slight increase can be observed, whereas regarding the control group, a slight decrease can be observed. Furthermore, the variation of those estimations is becoming less for the KieWi children but larger for the control group children.

	self concept of abilities			
KieWi	**M**	**N**	**s**	**Md**
t_0	3.28	100	.483	3.4
t_1	3.24	73	.515	3.2
t_2	3.34	61	.482	3.4
t_3	3.34	61	.546	3.4
t_4	3.39	38	.367	3.4
t_5	3.45	32	.373	3.4
control group	**M**	**N**	**s**	**Md**
grade 3	3.18	22	.660	3.4
4	2.95	67	.630	3.0
5	3.08	42	.533	3.2
6	2.89	130	.651	3.0

Table 3. Changes of self concept from beginning (t0) to follow up (t5) of the KieWi children and the comparison of the KieWi results with the results of the control group (estimated and differentiated according to grade)

Item example: I often think I am not gifted enough.
strongly disagree (1) ...disagree (2) …agree (3) …strongly agree (4)

Pupil's assessments of their motivational learning environment

The scales satisfaction (IDEAL α=0.69; REAL α=0.81) as well as opportunities to participate (IDEAL α=0.72; REAL α=0.55) were ranked highest from KieWi children and control group children (Table 4).

	satisfaction			**opportunities to participate**		
	IDEAL	REAL	wish to reality difference	IDEAL	REAL	wish to reality difference**
KieWi	**M**	**M**	**ΔM**	**M**	**M**	**ΔM**
t_0	3.83			3.62		
t_1		3.69	.16		3.73	-0.08
t_2		3.61	.16		3.75	-0.17
t_3		3.68	.15		3.72	-0.19
t_4		3.74	.10		3.73	-0.24
t_5^*	3.68	3.34	.33	3.61	3.33	.26
control group	**M**	**M**	**ΔM**	**M**	**M**	**ΔM**
grade 3	3.58	3.65	-0.11	3.53	3.40	.03
4	3.73	3.53	.24	3.58	3.71	-0.18
5	3.62	3.26	.43	3.62	3.42	.22
6	3.57	3.20	.35	3.53	3.32	.18

Table 4. Changes of the assessments regarding two selected scales of the motivational learning environment from beginning (t0) to follow up (t5) differentiated by the intervention (KieWi) and the control group children *t5 applies to lessons in school

Item example REAL: *In the KieWi course, I feel…*
very comfortable ☐☐☐☐ *not comfortable at all*
Item example IDEAL: *To me, feeling comfortable in the KieWi course is...*
very important ☐☐☐☐ *not important at all*

The motivational learning environment in the KieWi course has been classified as positive in general. The KieWi children particularly appreciate their options to participate and pursue their own ideas. However, especially this point is missed in science education according to the KieWi children (t_5) who now assess their school science lessons, and according to the control group children.

Pupil's assessments of their methodical preferences

When asked for their methodical preferences in science education, distinct changes in the KieWi children's preferences could be observed (Figure 2).

Activities that allow for more self-determination (such as working in groups, experimenting independently) are more and more preferred. Activities such as watching the teacher doing an experiment or answering short questions of the teacher are more and more disliked.

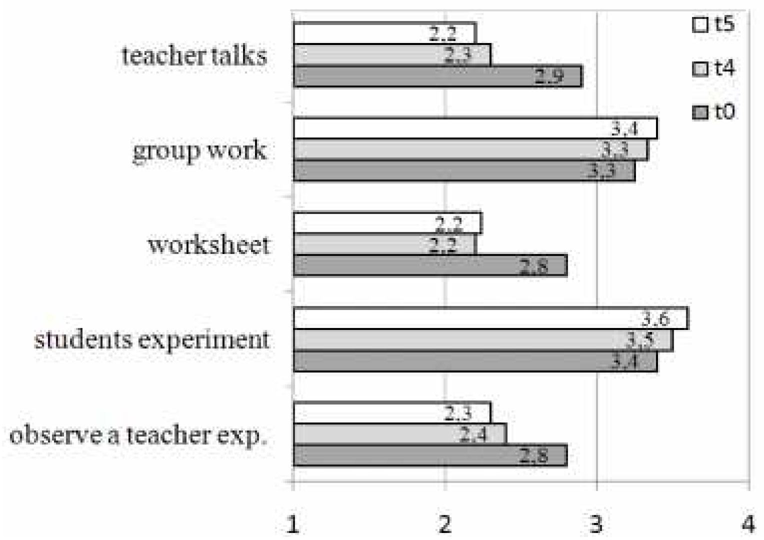

Figure 2. Changes of methodical preferences (a selection of 5 from 10 items is shown) from beginning (t0), after 2 years KieWi-course (t4) and follow up (t5)

Item example: *How do you like the following methods?*

very badly (1), badly (2), much (3), very much (4)

SCIENTIFIC AND SCHOLARLY SIGNIFICANCE OF THE STUDY

Our courses make it possible to positively influence the interests of the KieWi children to learn science. An increasing confidence in dealing with scientific data and tasks in specific ways is noticeable after a year of course participation. The children of the control group in primary school classes are also open-minded regarding the natural sciences and regarding science education and they, too, have confidence in their scientific capabilities particular in early grades. But comparing the results of the grade 5 control group with those of grade 6 it becomes obvious that this confidence decrease from grade 5 to grade 6.

On the basis of the positive findings in the survey of the KieWi children, we want to test now course sequences of the KieWi courses in regular school science lessons. Consequently, the question arose in what way the concept of the KieWi & Co. courses can actually be transferred to primary school. To find an answer to this question we have already started cooperations with primary schools and primary school teachers and established a long term teacher training with monthly workshops (Streller, Erb, Bolte, in press).

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CHEMISTRY-SPECIFIC LANGUAGE AND HOW IT INFLUENCES UNDERSTANDING OF CHEMISTRY CONTENT

Nermin Tunali and Elke Sumfleth

Abstract: The purpose of this study is to investigate if competence in chemistry-specific language is a pre-requisite for achievement in chemistry and if advancement in chemistry-specific language facilitates content learning. Therefore, data will be collected with a pre-post by control group design from a thousand grade 7 students at upper secondary schools and comprehensive schools in North Rhine-Westphalia. In the pre and post test students' language skills in the school language (L_S) and in the chemistry-specific language (L_C) will be measured and an achievement test will be administered. In addition, in the pre test data on cognitive abilities, interest and social background will be surveyed to serve as control variables. To measure the level of chemistry-specific language a C-Test was developed and will be used. In the training study one group will be trained emphasizing the acquisition of chemistry-specific language and the other one will be trained with a more traditional emphasis on chemistry content. Finally, the results of this study will give hints how to construct subject-specific language- sensitive assignments and how to support students' subject-specific language skills.

Keywords: school language, chemistry-specific language, chemistry achievement

1. INTRODUCTION

The results of international large scale assessment studies such as TIMSS and PISA confirm the importance of language skills, in this case of German as the language spoken at school, to follow the lessons at German schools, to learn contents and at the same time to be able to acquire key competencies (Hopf, 2005; Prenzel et al., 2005; Ramm et al., 2004). These studies show that students in Germany, regardless of a migration background, have difficulties in subject-specific text comprehension. Although the results concerning reading skills of students with migration background have improved significantly from PISA 2000 to PISA 2009, the difference between students with and without migration background remains big. Another important result of PISA 2009 is that the influence of the language spoken at home on reading skills has decreased. In PISA 2000 students who spoke a language other than German at home earned 60 points less in reading skills compared to native German students, while the difference in PISA 2009 has decreased to 24 points. This improvement can be explained by an increased focus on support of language skills since the publication of PISA 2000 (Stanat et al., 2010).

Everyday language is different from subject-specific language (Spanhel, 1980; Priesemann, 1971) or the language which is used in textbooks, which predominantly equals subject-specific language. Therefore, understanding the key concepts of the subject is not only difficult for students with migration background (Deppner, 1989) but also for German students. So, they should be supported in their language skills, too (Baur & Spettmann, 2007). In addition, in a comparison of students with Turkish migration to students with different migration backgrounds, Turkish-stemming students were outperformed with regard to their basic language skills in German (listening, speaking, reading and writing) (Köller, Knigge & Tesch, 2010). Accordingly, students with and without migration background should be empowered to use everyday language competently as well as they need to learn the subject-specific language to learn content knowledge. Subject-specific language is not a part of everyday language. Therefore the students should be trained explicitly how to use subject-specific language (Lemke, 1993).

Above all, the project's focus is on linguistic aspects of science education. Merzyn (1998) points out that learning is depending to a high degree on linguistic performance. Likewise, Yore and Treagust (2006) emphasize that students have to be able to use basic language skills to be able to learn the subject content. This problematic interference of language worsens even as students have to learn an additional subject-specific language in chemistry classes. Learning a subject is always inextricably linked with learning its language. Classes can address these issues on two different levels, the level of spoken language and the level of written language (Merzyn, 1998).

2. METHODS

2.1. Hypotheses

The purpose of the study is to investigate the effects of a competent use of subject-specific language on learning chemistry content and the differences caused by language skills between students with and without migration background. Thus, the following hypotheses will be tested:
H1. Students who use chemistry-specific language (L_C) more competently perform better in chemistry.
H2. Students who are trained specifically in chemistry-specific language are better in chemistry than students who have worked only on the chemical content.
H3. Students who are trained specifically in chemistry-specific language are better in chemistry-specific language than students who have worked only on the chemical content.
H4. Students who are trained to use subject-specific language will improve their use of school language (L_S).

2.2. Design

The presented study consists of two parts and is conducted with a pre-post design.

Part A: Selection of students for the training study

The total sample consists of 1000 grade-7-students from upper secondary schools (German *Gymnasium*) and comprehensive schools (German *Gesamtschule*). In order to measure the language skills in the school language (L_S) and in chemistry-specific language (L_C) C-Tests (see Chapter 2.3.) are administered. Moreover, chemistry achievement data are collected. In addition, in the pre-test data are collected with regard to the following control variables: cognitive abilities, interest and a questionnaire on socio-economic background. Students who will be supported in their chemistry-specific language acquisition will be divided in groups on the basis of the results of a chemistry-specific language test (C-Test L_C) and a school language test (C-Test L_S) (see Figure 1).

Pre-Test C-Test L_S, L_C , achievement test, cognitive abilities test, interest, socio-economic background questionnaire		
Level of language	**Training**	
	Training focusing on content knowledge in chemistry	Training focusing on chemistry-specific language
L_s (+) & L_c (-)	**A**	**B**
L_s (-) & L_c (-)	**C**	**D**
L_s (+) & L_c (+)	**E**	**F**
Post-Test C-Test L_S, L_C, achievement test		

Figure 1: An overview of design and instruments

Part B: Training study

Based on these data, six groups (A, B, C, D, E, F) of 100 students are formed. Each group ideally is composed of 50% German-speaking students and 50% Turkish-speaking students (see Figure 1). Subsequent to the intervention, students who have been specially supported in learning the subject-specific language in chemistry will be compared in their learning achievement with students who have worked with a more pointed emphasis on the chemistry content.

2.3. Instruments and teaching materials

C-Test:

C-Test (Cloze-Test) is based on the principle of *reduced redundancy* (Klein-Braley, 1997). To date, various types of C-Tests which are based on this principle have been developed and used (Baur & Spettmann, 2007; Grotjahn, 2006; Coleman, Grotjahn & Raatz, 2002). In this study, a C-Test for grade 7 (Baur & Spettman, not published) will be used to measure language level in the school language (i.e. German).

The C-Test typically consists of a collection of four texts, each of which embraces twenty to twenty five gaps (80-100 gaps in total) that need to be completed by the students. In each of the texts, every sentence but the first and last sentences are affected by gaps. These gaps are formed by deleting the posterior half of every third word in the sentences (cf. Baur & Spettmann, 2007).

In order to measure the language level in chemistry-specific language an analogous C-Test L_c has been developed. In this C-Test L_c, only chemistry terms will be transformed into gaps. For this purpose, chemistry textbooks which are used at upper secondary schools and comprehensive schools have been analyzed concerning the chemistry terms used in them. The results of this expert rating distinguish chemistry specific-terms satisfactorily from non-specific terminology ($\kappa = .76$; Wirtz & Caspar, 2002).

Teaching materials for the training:

Worksheets for both training groups have been developed. The same content is taught in both groups including these topics:

- Material and their properties
- Physical states of matter

- Mixtures and solutions
- Separation processes

The worksheets that will be used to support the chemistry-specific language were developed according to Leisen (2010).

3. PRELIMINARY RESULTS OF THE PILOT STUDY

The total sample of the pilot study consists of 95 grade-8-students from comprehensive schools. They have learned with the worksheets for ten weeks. After the training a positive correlation between the chemistry achievement and the performance of chemistry-specific language was found. In addition, there is a correlation between school language and chemistry-specific language, but just for the topics "Materials and their properties" and "Physical states of matter" (see Figure 2). This relationship can be explained by the similarity of terms with the everyday language. For example, the term "color" features in the subject area "Material and their properties" as a chemical term but students use the same word also in their everyday language. Likewise, the low learning growth in the subject areas "Material and their properties" ($t(42) = .211$, $p = .834$) and "Physical states of matter" ($t(39) = -.831$, $p = .411$) could be explained with these overlaps of everyday language and chemistry-specific language.

Post-Test	
Chemistry achievement – Chemistry-specific language	**Correlations**
Materials and their properties & Physical states of matter	$r_S = .399^*$, $p < .05$
Mixtures and solutions & Separation processes	$r_S = .334^*$, $p < .05$
School language – Chemistry-specific language	
Materials and their properties & Physical states of matter	$r_S = .424^{**}$, $p < .01$
Mixtures and solutions & Separation processes	n.s.

Figure 2: Spearman's correlations

Furthermore, comparisons of means indicate a significantly higher learning growth for the group trained in chemistry-specific language. Yet, this finding is restricted to the topics "Mixtures and solutions" ($t(25) = 3.181$, $p < .01$) and "Separation processes" ($t(14) = 2.301$, $p < .05$).

4. DISCUSSION AND CONCLUSIONS

The preliminary results of the pilot study show that the chemistry-specific language has an influence on the chemistry achievement. In addition, the results provide evidence that there are differences and overlaps between school language and chemistry-specific language. Moreover, the results show that the training on chemistry-specific language produces positive effects in the subject areas "Mixtures and solution" and "Separation process" concerning the competent use of chemistry-specific language. Based on results of the pilot study the worksheets for the subject areas "Mixtures and solutions" and "Separation process" will be used in the main study to examine the effects of the training on chemistry performance, school language and chemistry-specific language.

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PART 11: CULTURAL, SOCIAL AND GENDER ISSUES

Editor: Helene Sorensen

Equity and diversity issues: Sociocultural, multicultural, bilingual, racial/ethnic, gender equity studies and science education for the special needs.

This part corresponds to strand 11. It contains 8 papers.

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CULTURAL, SOCIAL AND GENDER ISSUES

PLAY WITH SCIENCE IN INQUIRY BASED SCIENCE EDUCATION

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Abstract: In science education students sometimes engage in imaginary science-oriented play where ideas about science and scientists are put to use. Through play, children interpret their experiences, dramatize, give life to and transform what they know into a lived narrative. In this paper we build on the work of Vygotsky on imagination and creativity. Previous research on play in primary and secondary school has focused on play as a method for formal instruction rather than students' spontaneous informal play. Our aim is to explore students' informal play as part of activity in lower secondary school science. The empirical study was conducted as part of a larger study on learning, narrative knowing and remembering in inquiry based science education in two Swedish compulsory schools. Data were collected during 10 weeks using video- and audiotape recordings. Our analyses of play show that the students step in and out of play when engaging in task completion. Play offers opportunities for sense-making, opposition and exploration of ways of enacting science identities. Implications for teaching science are that teachers, in order to promote students' learning about science as a cultural endeavor and students' learning about themselves in relation to science and scientist communities, may encourage students' informal play.

Keywords: informal play, science learning, inquiry, lower secondary school

BACKGROUND AND FRAMEWORK

Lisa:	Now I'll do.
Gustav:	Here doctor, thirty seconds.

The above excerpt is an example of sixth grade students engaging in play activity along with their completion of a laboratory task of testing for glucose in different nutrients in 6th grade science class in a Swedish compulsory school. Gustav and Lisa engage in role-play of a doctor and an assistant. Lisa puts the testing stick in the investigated food and Gustav counts to thirty. This play involves making use of what they know about testing, possible social roles and science culture. Through play, children interpret their experiences, dramatize, give life to and transform what they know into a lived narrative. Children's play is not just simple remembering but a creative transformation of the experienced – creating a world that meets the needs and interests of children (Vygotsky 1930/2004). In science education students sometimes create and engage in imaginary science-oriented play where ideas about science and scientists are put to use. Students create imaginary situations by combining experiences available to them; be it personal experiences or someone else's historical or social experiences made available through narratives, literature, media etc (Vygotsky 1930/2004). These play activities open opportunities for students to explore ways of positioning themselves in relation to science. A scrutiny of informal play activities is therefore also a scrutiny of science classrooms as places where identities are developed through students' engagement in activity (cf. Kelly & Sezen 2010; Wenger 1998).

Here, we investigate students' self-initiated spontaneous play as part of everyday culture in science education, how it emerges and in what ways it opens up for students to explore ways of positioning themselves in relation to science and science education. Our aim is to explore students' spontaneous informal play as part of activity in lower secondary school science in order to contribute to our understanding of processes of learning science in school science practices.

Previous research on play and science learning

There is an extensive literature on play in general in particular related to pre-school (e.g. Lindqvist, 1996; Moyles 2005; Singer, Hirsch-Pasek & Golinkoff 2006). In relation to science education, however, research is rather scattered. In our review of previous research we discern different approaches to the analyses of play and science learning which may, at least partially, be understood in relation to the researchers being engaged in studying different parts of the educational system.

In relation to compulsory school science education there has been an interest in play as part of instruction in terms of role-play and computer-games. McSherry & Jones (2000) argue that role-play in science lessons is underrated and underused and attempt to provide a theoretical basis for the use of role-play as part of developing the experiential side of teaching science. Simulation-role-play is held by Aubusson, Fogwill, Barr and Perkovic (1997) to allow students to demonstrate their understanding, explore their views and develop deeper understanding of phenomena although they raise concerns about students' capacity to distinguish role play from the subject matter being studied. Burton (1997) provides detailed steps to guide teachers through the process of role-play in order to enhance learning in science. With the growth of educational computer games and programs emphasis has been placed on play with computer programs (as game-play) as instructional method (Roussou 2004; Steinkuehler & Chmiel 2006; Barab, Sadler, Heiselt, Hickey & Zuiker 2007).

In pre-school, play – in particular 'free play' – has been recognized as an important part of learning in general ever since Friedrich Fröbel's work in the early 1800's (Lindqvist 1996). The role of the pre-school teacher is described as a facilitator of children's play (op cit). In relation to science learning there are few studies of play. Henniger (1987) analyzes learning opportunities in science and mathematics available through children's play. In particular he studies what attitudes to learning science are developed through play. However, Goldhaber (1994) reports on pre-school teachers expressing insecurity in relation to whether children may be allowed to play if the activity is to be called science.

In relation to learning science at university, Hasse (2002) has shown that play as science preparation is very much part of learning physics. She showed that games, like creating new experiments rather than adhering to given tasks, prepare students, boys in particular, for lives as scientists, and allow students to play out their imagination.

The research initiatives on play and science education differ in relation to different forms of education. Hasse's (2002) study on play in university physics focus on informal play as an integral part of learning science whereas studies of school science focus on formal instruction. Research on play in pre-school science take a semi-formal approach recognizing informal play as mediating formal learning. However, there is little reason to expect that informal play would be of less importance as an integral part of learning science in school as compared to learning science at university. Even though there may be important differences relating to the goals and motives of educational activity in different forms of schooling.

Play in a Vygostkian perspective

Here, we use Vygotsky's notion of play as imagination in action to develop a framework for discerning and theorizing moments of play in the science classroom. Vygotsky elaborated the theory of play in his essay "Play and its role in Mental Development of the Child" (1933/2002) and in his book "Imagination and Creativity in Childhood" (1930/2004). Vygotsky characterizes play in terms of involving 1) an imaginary situation and 2) rules implicit in the imaginary situation. Through play imagination is enacted socially and collectively. The imaginary situation created in play is free of constraints of the real situation and allows the child to meet its desires (Vygotsky, 2002).

Vygotsky (2004) argues that it is not possible to draw a strict line between imagination and reality. Everything created by imagination is based on elements in reality, from a person's previous experiences or experiences shared by other people (op cit). However, children's play is not a simple reproduction of prior experiences but a creative reworking of experiences which is combined to construct a new situation that conforms to the child's own needs and desires (op cit). Thus, imagination becomes a means to broaden a person's experience because he can imagine what he has not seen and may conceptualize something from another person's narration and description of what he himself has never directly experienced (cf. Ferholt, 2007).

RESEARCH QUESTIONS

This paper reports from a larger study on learning, narrative knowing and remembering in inquiry based science education (IBSE). Hence, we focus specifically on play in IBSE. The main research questions addressed are: How and when is play initiated by students in lower secondary IBSE? In what ways is play used by students to overcome situational constraints? What affordances do students' engagement in play open up for?

METHODOLOGY

The study was conducted in two Swedish compulsory schools (school A and B). School A is situated in a relatively prosperous residential community and school B in a less advantaged suburban community. In each school we followed one teacher and their 6th grade class working with the unit 'Chemistry of food' in the curriculum material *Naturvetenskap och teknik för alla*, NTA (in English *Science and Teachnology for all*). The unit covered a period of about 10 weeks. Data were collected throughout the 10-week-period using video- and audiotape recordings of classroom work (in all app. 55 h). The audiotape recordings were transcribed verbatim with the video recordings used as support.

Vygotsky's (2002; 2004) theory of play has provided the beginning point for examining play and/or invitations to play in the studied classrooms. We have operationalized play in our analyses of data as situations where at least one of the following criteria is met:

- a student tries to act as someone i.e. positions him- or herself *as* someone,
- a student positions a co-student *as* someone,
- an object becomes pivot i.e. separated from its original meaning and ascribed new meaning in an imaginary situation and
- a student enact rules/norms of action that transcend the given tasks.

When analyzing play we have been looking for play and invitations to play. Important to note is that invitations to play sometimes fail.

RESULTS

Play with science and tasks of the science classroom appear to be an integral aspect of the everyday culture of the school science classroom. In data of students working with investigating *the Chemistry of food* we found several examples of play or invitations to play even though it is evident that play is not a leading activity. Out of the 26 analyzed group discussions there is play or invitations to play in 10 groups. Our analyses of play show that the students step in and out of play when engaging in task completion. Albeit transcending some situational constraints the students enact play within boundaries of given school tasks. Students engaging in play are simultaneously well attuned to constraints of task completion. Play offers opportunities to explore e.g. different ways of positioning as a researcher, a doctor, an assistant.

In the following we will exemplify our analyses by means of the introductory transcript of doctor-assistant play. In this example play emerges as a subtle process where Lisa and Gustav initiate play by use of a slightly different tone of voice or gesture. Lisa and Gustav begin initiating a doctor-assistant play in setting up a division of labor; in the way they deal with the measuring stick and the food to be investigated. They start taking turns measuring with the measuring stick and pouring the food in a cup: "I'm supposed to pour out and you take the stick". Some minutes later they switch.

Gustav then makes the play situation explicit in a comment on a negative test result saying: "None of these substances here have glucose. Is this normal? No, I'm kidding". When saying "is this normal" with a lower more formal tone of voice he steps into the doctor position of the play. By the following comment that he is kidding, Gustav marks his previous utterance as play and again steps out of the play situation.

The play situation is brought to the fore again ten minutes later when Lisa takes over the responsibility for measuring:

Lisa:	Now I'll do.
Gustav:	Here doctor (hands the measuring stick to Lisa) thirty seconds.

The studied IBSE practices offer students a relatively rich variety of resources combined with a lesser degree of discursive control as compared to whole-class teaching. These conditions open up possibilities for students to engage in self-initiated play. Resources that become pivot are both measurement instruments (e.g. the stick for measuring glucose) and objects of students' investigations (e.g. wheat flour in a case where a girl invites her group mates to play that they are preparing a dough to bake buns).

We find that the students in our studied classrooms step in and out of play when engaging in task completion. E.g. a group of boys create an imaginary situation when they measure fat in water. These boys play with the idea of actually discovering fat in water and the possibility of receiving the Nobel Prize. They explicitly negotiate the play situation and explicitly step in and out of the play situation.

CONCLUSIONS AND IMPLICATIONS

In conclusion, imagination and play are important dimensions of classroom life. Our findings contribute to the understanding of how learning in the school science classroom is embedded in social and cultural-historical practice, and how individual students' engagement in play contribute to transforming and transcending classroom practice. Play offers students opportunities for creating situations in the school science classroom that meets the needs and interests of the students. Play offers opportunities for sense-making, opposition and exploration of ways of enacting science identities.

When students engage in play they transform the given tasks in relation to needs and motives that are personally meaningful to them. Hasse (2002) showed that play activity is part of university physics students' preparation for a scientific career and that play enable students to learn hidden rules of science. Our examples of play in the lower secondary IBSE classroom are not only examples of ways of making meaning in relation to becoming a scientist but also examples of students distancing themselves in relation to the science content as in game-play. A teacher may promote students learning about science as a cultural endeavor by facilitating and encouraging students' exploration of different ways of positioning themselves in relation to science and a community of scientists in spontaneous play.

This study opens up for further studies on play as an aspect of everyday school culture. When we have analyzed our data a feel emerged that students who do engage in play have more fun in the science classroom. Investigating students' trajectories of play in relation to participation and motive development is one question for further research that may advance educational researchers' understanding of education.

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THE INFLUENCE OF RELIGION ON PORTUGUESE AND BRAZILIAN TEACHERS' CONCEPTIONS ABOUT THE ORIGIN OF LIFE.

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Abstract: Teachers' conceptions about human evolution have been a matter of intense research by Quessada and Clément (2010) in the context of the European BIOHEAD-CITIZEN project. Having in mind the socio-cultural links between Portugal and Brazil, in the present paper we extended the BIOHEAD-CITIZEN study to Brazilian teachers and compared with the equivalent Portuguese sample. The BIOHEAD-CITIZEN questionnaire was applied to 368 teachers and future teachers from Braga district (Portugal-Pt) and 300 from S. Paulo State (Brazil-Br).

Results show a stronger influence of religous values in the Brasilien group as compared with the Portuguese one, though both groups are aware of the natural selection role in evolution theory. Furthermore, significantly ($p<0.05$) higher percentage of Brazilians (67.0%) refer God as being in the origin of mankind as compared with the Portuguese (45.5%). Similarly, 73.3% of the inquired Brazilians believe in God influence for the creation of life as compared to 49.2% of the Portuguese respondents. Although the Portuguese cultural influence in Brazil is strong (for about 500 years and having the common Portuguese language), these results show that the Brazilians, rather than the Portuguese, put in evidence their religious values, which comes along with the existence of more Agnostic/Atheist in Portuguese (9.4%) than in Brazilians (6.4%) samples.

Keywords: Evolution, Creationism, Human origin, Teachers' conceptions.

INTRODUCTION

The teaching of Evolution of life on Earth, particularly the Human origin, is a matter of great concern nowadays and in some countries it has been "*concealed, denied, or confused with theories not testable by science*" (IAP, 2006: 1). In a large study involving 14 countries, Quessada and Clément (2010) have shown that national school programmes of four countries (Algeria, Burkina Faso, Lebanon and Morocco) never mention biological evolution, whereas other ten countries refer it either in upper secondary school only (Cyprus, Romania, Senegal and Tunisia) or in primary and secondary school (Estonia, Finland, France, Hungary, Italy and Portugal). Regarding specifically Human Evolution, only eight of these fourteen countries refer it in their school programmes. In other countries, as in Greece, Human Evolution is present in the national programme but often it is not taught in school (Lakka & Vassilopoulou, 2004; Prinou, Halkia & Skordoulis, 2007). Other studies about teaching Evolution have taken place in several other countries – in Spain (Jimenez-Aleixandre, 1994, 1996; Barberá, Beatriz & Pérez-Pla, 1999), in China, USA and URSS (Swarts, Anderson & Swetz. (1994) – often assuming the importance of the social context for the national programmes and textbooks contents (Skoog, 2005).

In a large European project BIOHEAD-CITIZEN ("Biology, Health and Environmental Education for better Citizenship" – FP6-STREP CIT2-CT-2004-506015) involving 19 countries from Europe, Africa and Middle East (Carvalho, 2004; Carvalho and Clément, 2007), the interactions between social context factors and teachers' conceptions about Evolution has been a matter of research by Quessada and Clément (Quessada et al, 2007; Quessada, 2008; Clément & Quessada, 2008, 2009 – all referred in Clément & Quessada, 2010), putting in evidence the degree of believing in God and of practicing religion, the country economical level and the teachers' level of training.

Having in mind that Brazil was a Portuguese colony until 1822, having high cultural influence (especially the common Portuguese language) but also with strong differences (especially the multiculturalism in Brazil), in the present study we extended the BIOHEAD-CITIZEN study to Brazilian teachers and compared to the equivalent Portuguese sample, focusing on the religious beliefs in the origin of life and human kind.

METHODOLOGY

The BIOHEAD-CITIZEN questionnaire used in this work has been validated and applied to several countries (Carvalho & Clément, 2007; Munoz et al. 2009) was applied to teachers and future teachers from Braga district (Portugal-Pt) and from S. Paulo State (Brazil-Br). In either country the questionnaire was applied to six samples of pre-service teachers (Pre) and in-service teachers (In) of primary school (P), and of secondary school, teaching Biology (B) and Portuguese (the national Language, L). This makes six subsamples in each country (Pre-P, In-P, Pre-B, In-B, Pre-L and In-L) which were well balanced as shown in Figure 1.

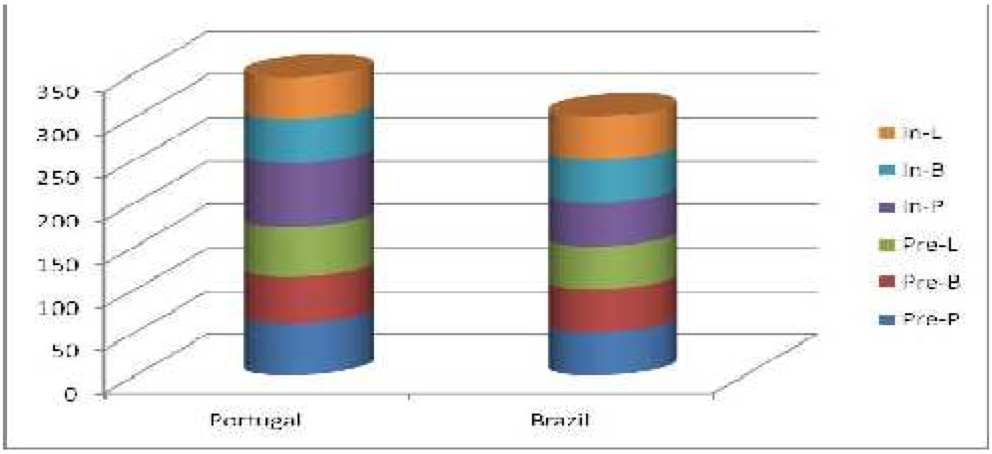

Figure 1: Teaching group distribution in both Portuguese and Brazilian samples.

The sample size (368 Pt and 300 Br), the percentage of women (82% Pt and 88% Br) and the age mean (32 years old either Pt or Br) show the good balance between both Portuguese and Brazilian samples. Figure 2 shows the age distribution of Portuguese and Brazilian participants, where the 21-30 years-old group is the largest one in both samples.

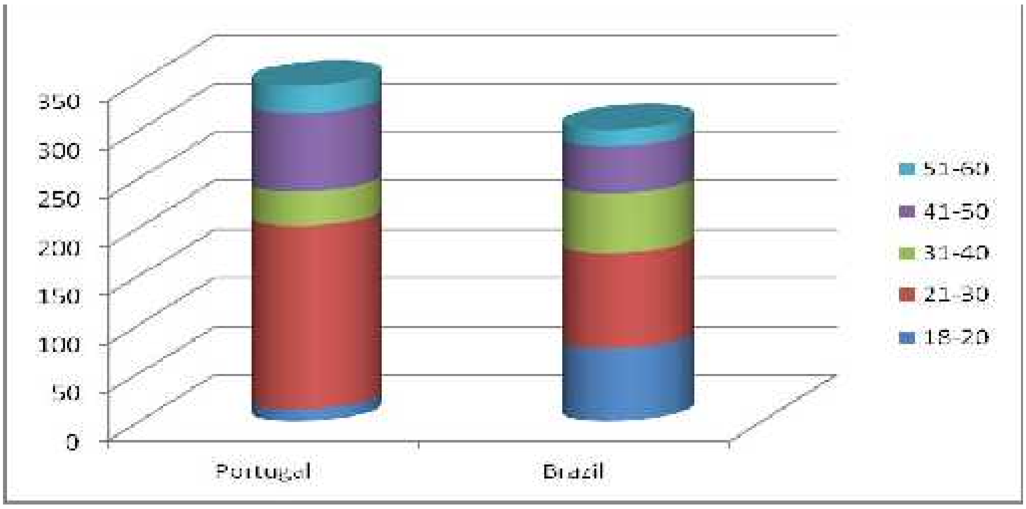

Figure 2: Age distribution in both Portuguese and Brazilian samples.

RESULTS AND DISCUSSION

The majority of responders in both countries were shown to be Catholic (76.4% Pt and 67.4% Br), but Protestants (7.4% Pt and 11.1% Br) and Agnostics/Atheists (9.4 Pt and 6.4 Br) were also present in both samples, whereas Muslims and Jewish were absolutely absent (Figure 3).

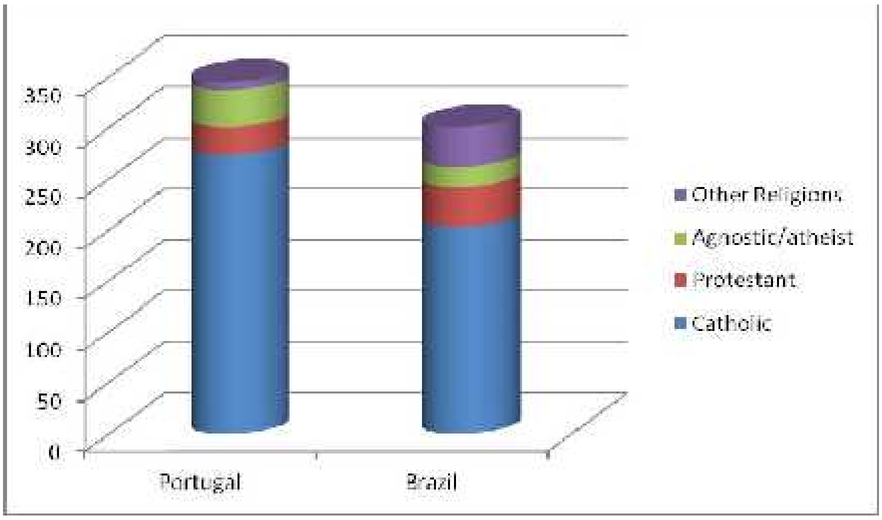

Figure 3: Religious faith distribution in both Portuguese and Brazilian samples.

When asked about believing in God (likert scale: from "I believe in God" to "I don't believe in God") results showed the Brazilians were greater believers than the Portuguese (Figure 4A.) The participants were also asked about their level of religion practice (likert scale: from "I practice religion" to "I don't practice religion") and the Brazilian group said to practice more than the Portuguese did (Figure 4B).

A B

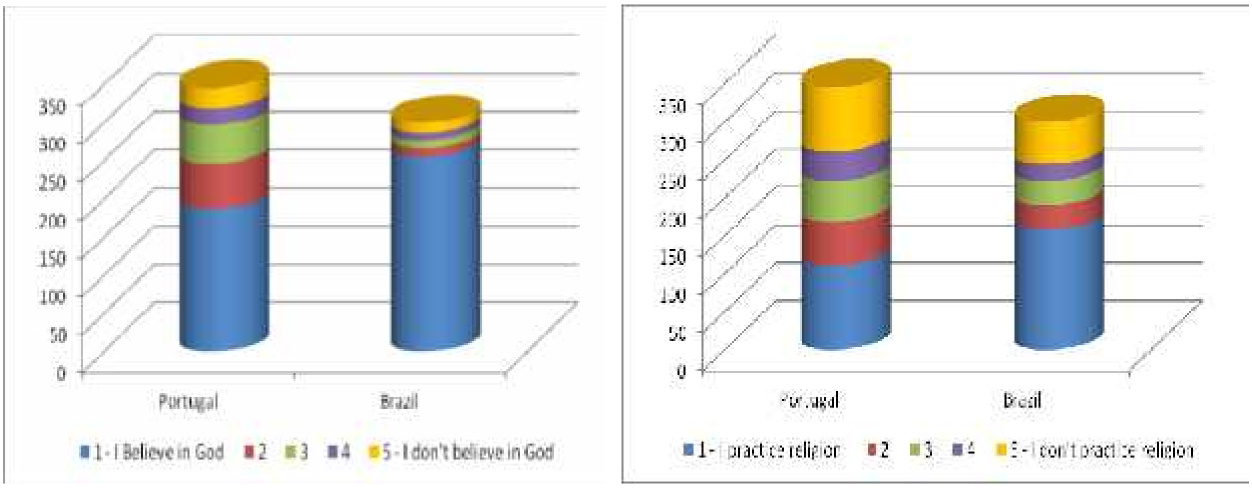

Figure 4: God believers (A) and religion practice (B) in both Portuguese and Brazilian samples.

Of the 15 questions on Evolution, questions A64, B28, B43, B48 were those with stronger contribution for the axes in the principal components analysis (PCA). Therefore they were preferentially chosen to be used for the comparative analysis on Evolution conceptions between Portuguese and Brazilian samples. The statistical analysis was carried out by using the Software Package for Social Sciences (SPSS, version 17).

For the analysis we put the itens "Great importance" and "Some importance" together, contrasting with the itens "Little importance" and "No importance at all" also put together. The answers of Portuguese and Brasilien respondents show that the former (46.8%) give significantly ($p<0.05$) lower importance than the latter (78.6%) to the importance of "God" in species evolution (Question B48, Figure 5A). However, both groups do not differ signifcantly ($p>0.05$) about the importance of the "Natural Selection" in the evolution process: 94.0% and 86.3% of the Portuguese and Brasiliens responders, respectively (Question B43, Figure 5B).

A – B48 **B – B46**

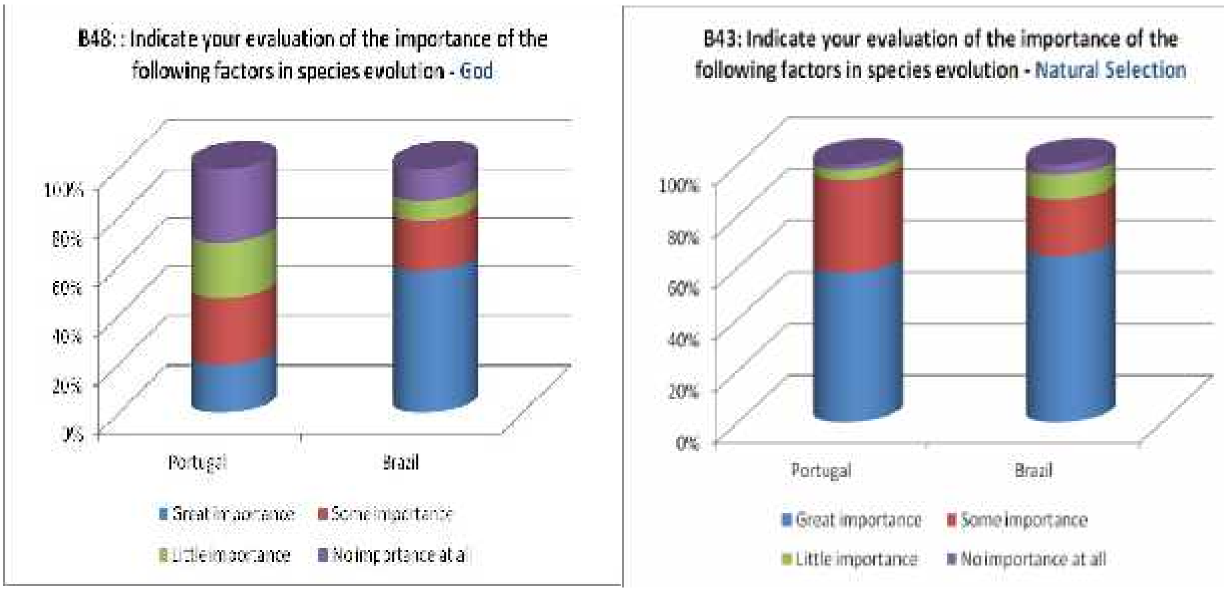

Figure 5: Proportion of Portuguese and Brazilian responders to questions B48 (God influence in evolution) and B43 (Natural selection in evolution).

These results show a stronger influence of religous values in the Brasilien group as compared with the Portuguese one, though both groups are aware of the natural selection role in evolution theory.

Similarly, a significantly ($p<0.05$) larger percentage of Brazilians (67.0%) refer God as being in the origin of mankind as compared with the Portuguese (45.5%) (Question B28, Figure 6A). This is in agreement with the Question A64 (Figure 6B) where, again, 73.3% of the inquired Brazilians believe in God influence for the creation of life as compared to 49.2% of the Portuguese respondents.

A – B28 **B – A64**

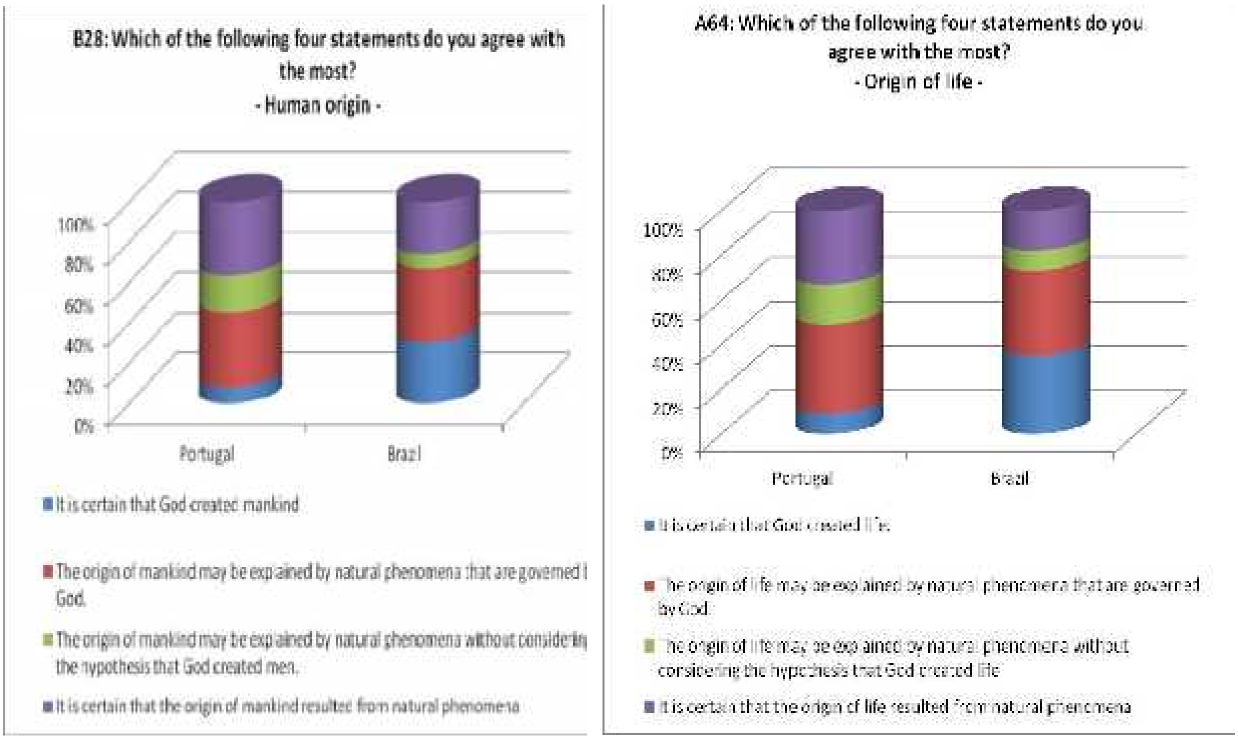

Figure 6: Proportion of Portuguese and Brazilian responders to question B28 (God influence in humankind evolution) and A64 (God influence in life origin).

Although the Portuguese cultural influence in Brazil is strong (for about 500 years and revealed by the common Portuguese language), these results show that the Brazilians, rather than the Portuguese, put in evidence their religious values, which comes along with the existence of more Agnostic/Atheist in Portuguese (9.4%) than in Brazilians (6.4%) samples. Really interesting is the fact that more Portuguese (84.4%) than Brazilians (81.2%) declared to be Christians, although their religious convictions seem to be irrelevant regarding the evolution process. In fact these results confirm our preliminary studies (Araujo et al., 2009; Caldeira et al., 2010) showing that Brazilian teachers live with the evolutionist and creationist conceptions, apparently without conflict.

ACKNOWLEDGEMENTS

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DIFFICULTIES CHEMISTRY STUDENTS EXPERIENCE DURING THEIR FIRST SEMESTER
- *PREDICTING SUCCESS* -

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Abstract: It is generally known that student success in chemistry is rather low. Approximately one fourth of freshmen will not succeed the course in general chemistry that is offered in the first semester of studies. Regarding the entire course of university studies - from the first through the last semester - this low student success is also reflected in dropout rates, since approximately every third student ends their studies before completion.
This study investigates the qualification first-semester students in chemistry bring to university. To do this, questionnaires have been developed to determine the students' attitudes towards their studies, their cognitive abilities, and their subject-specific qualifications at the very beginning of the first semester. At the end of the first semester, results from the final exam were obtained and the students were divided into two groups: those who passed the exam and those who failed. With the help of binary logistic regression, the passing of the final exam was able to be predicted. The grade from their secondary school graduation certificate, scores from a chemistry knowledge test and a test for measuring deductive thinking as well as the course of study could be included in a regression model correctly collating 77.7 % of freshmen to the successful and less successful student groups, respectively.

Keywords: Chemistry, freshmen, difficulties, prediction of success, binary logistic regression

INTRODUCTION

The rate of German university students dropping out of chemistry without changing to another subject amounts to 31 % (Heublein, U. et al., 2010). Most students leave university due to difficulties in performance and lack of motivation (Heublein, U. et al., 2010) caused by false expectations of their studies (Heublein, U.; Spangenberg, H. & Sommer, D., 2003). The highest dropout rates in natural sciences studies are found during the first semesters at university (Heublein, U.; Spangenberg, H. & Sommer, D., 2003) since the beginning of studies is accompanied by a great number of problems, like adjusting to a new environment and social challenges that have to be managed all at once (Gerdes, H. & Mallinckrodt, B. 1994).
This dropout rate problem is not specific to Germany: Other European countries have excessively high dropout rates as well. Ulriksen, Møller Madsen & Holmegaard (2010) state that around one third of students end up their studies before the scheduled time.
Low student success is an important issue at American universities as well, as only approximately 70 % of freshmen in chemistry pass the final exam in general chemistry at the end of first semester (Legg, Legg & Greenbowe, 2001; McFate & Olmstedt, 1999).
There exists the need to find factors that, as soon as studies begin, can identify those students who will be able to pass their studies and those who will not.

There have been a lot of approaches for determining the factors leading to success. The attempts date back to 1921 (Powers, 1921). Up to now, several variables predicting success have been identified. These are performance parameters such as grades from the secondary school graduation certificate, scores from ability and knowledge tests, as well as personality parameters (Rindermann & Oubaid, 1999).

The highest predictive strength as a single predictor has been attributed to the grade from the secondary school graduation certificate (*Abitur*), which is a measure for the general domain-*un*specific study ability. Likewise, pre-knowledge has been intensively surveyed, usually by achievement tests. Its predictive strength is less than that of the final school grade, but increases with rising consistency of test and study content (Heine et al., 2006). Furthermore, abilities in deductive thinking are seen as central factors in measuring cognitive abilities, which show medium or satisfactory predictive strength (Heine et al., 2006). Ambiguous information can be found for personality scales like interest. Some studies show no predictive strength (Gold & Souvignier, 2005) whereas others find it meaningful (Giesen et al., 1986). Concerning gender, there is also inconsistent information for university students (Taasoobshirazi & Carr, 2008; Legg, Legg & Greenbowe, 2001). However, self-evaluation of one's own abilities is seen as an important predictor (Giesen et al., 1986), and the course of study can also have an influence on the students' position because of the different structures and requirements given (Preuss-Lausitz & Sommerkorn, 1968).

The aim of this project is to find variables that predict student success at the end of the first semester in chemistry using binary logistic regression and combining variables concerning both performance and personality of students. Only in few studies has this approach been applied.

For this purpose, questionnaires that survey a variety of variables have been developed. It is assumed that the secondary school graduation certificate grade will have most predictive strength, that pre-knowledge and abilities in deductive thinking will have less predictive strength and that subject interest, self-evaluation of abilities in chemistry, gender and course of study will possibly have some influence on student success.

Success is determined by passing the final exam in general chemistry at the end of the first semester.

STUDY DESIGN

A pilot study investigating the qualification and attitudes students in chemistry bring to university has been conducted.

Participants

The students were surveyed at the very beginning of their studies in October 2010. A total number of 241 students of the subjects B.Sc. Chemistry, B.Sc. Water Science and also chemistry education students who all take General & Inorganic Chemistry have participated in this survey. Table 1 shows the number of students who took part in the survey divided by course of study.

Table 1. Participants divided by course of study.

	Beginning of 1st semester October 2010	
Course of study	Frequency	Rel. frequency
B. Sc. Chemistry	55	23 %
B. Sc. Water Science	71	30 %
Chem. teach. stud. (GG)[1]	74	31 %
Chem. teach. stud. (HR)[2]	40	17 %
No answer	1	0,4 %
Total	241	100 %

Female (50 %) and male (49 %) students are equally present in the sample (1 % gave no clear answer). There are differences concerning the students' year of receiving their secondary school graduation certificate (*Abitur*). Thirty-seven percent did their final exam just before starting their studies in 2010; 31 % one year before in 2009 and 24 % earlier than that (8 % gave no clear answer).

Material

The survey contains several questionnaires. *Personal data* were collected concerning facts like grade from the secondary school graduation certificate (*Abitur*) and other demographic data.
The *Chemistry Knowledge Test* is an achievement test consisting of multiple-choice items. All tasks deal with knowledge that is taught during the first semester in chemistry at university. A further item asks for a self-evaluation of one's own performance on this test by giving one's self school grades.
The *Test for Measuring Deductive Thinking* is taken from Wilhelm, Schroeders & Schipolowski (2009). It consists of a verbal, calculative, and visual part.
The *Self-evaluation Questionnaire* asks for self-assessing the own capabilities and knowledge relevant for taking chemistry courses.

> Example: I think I am capable of solving tasks on the topic of acids and bases.

The purpose of the *Questionnaire on Subject Interest* is to examine the amount of interest the students have in their subject.

> Example: I'm studying this subject because engagement in chemical topics and matters is important to me.

For responding to the questionnaires on self-evaluation and subject interest, a four-point Likert scale is given for specifying one's level of agreement. Among the self-constructed items, there are also a couple of proven and tested ones from literature (Jerusalem & Schwarzer, 1986; Schiefele et al., 1993) for validation reasons. Validity and reliability (using Cronbach's alpha) for both scales, self-evaluation and subject interest, could be proven.

[1] Chemistry teacher students for intensified general education and comprehensive schools
[2] Chemistry teacher students for basic and extensive general education

Additionally, scores on the final exams in chemistry at the end of the first semester have been gathered. Students of B.Sc. Chemistry and B.Sc. Water Science took the same exam whereas the teacher students took different exams. Due to this fact, only the results of Bachelor students were used in the following analysis.
Out of the 241 freshmen who took part in the first survey in October 2010, only 175 also took the final exam; 95 of them were B.Sc. Water Science and B.Sc. Chemistry students.

RESULTS

In comparison to linear regression, logistic regression enables one to predict category-dependent variables. In this study, the binary variable *student success* ought to be predicted. Binary variables usually have the two values "0" and "1". Therefore, a successful student is characterized by passing the final exam at the end of the first semester and is assigned the value "1", whereas a less successful student, who does not pass the final exam at the end of the first semester, is assigned the value "0".

With the help of logistic regression it is possible to calculate the probability for every student to belong to the group of successful students.
The calculation is done by including a couple of independent variables in a regression model. The relationship between the independent variables (predictors) and the dependent variable is not linear, but built by a logistic function.

After determining the independent variables that have an impact on success in chemistry, the regression model was calculated using SPSS.
The result of the binary logistic regression is shown in Table 2. The most important value to interpret is Exp(β), which is called odds ratio and is the factor by which the probability of belonging to the successful student group increases when the independent variables rise by one unit. For example, the odds to be in the group of the successful students are 1.157 times higher for a student having one point more on the chemistry knowledge test than another student when all values of the other variables are identical. The same is true for deductive thinking. A student having one point more on the test for measuring deducting thinking than another student is 1.282 times more likely to be successful.

Table 2. Result of binary logistic regression for predicting success.

	β	SE	Wald	df	Sig.	Exp(β)	95% conf. int. EXP(β) Lower value	Upper value
Knowl. Test[3]	0.145	0.077	3.575	1	.059	1.157	0.995	1.345
Vis. Ded. Th.[4]	0.248	0.093	7.177	1	.007	1.282	1.069	1.538
Final grade[5]	-0.482	0.243	3.918	1	.048	0.618	0.383	0.995
Study Course[6]	1.643	0.539	9.278	1	.002	5.169	1.796	14.873
Constant	-3.110	1.581	3.869	1	.049	0.045		

[3] Chemistry knowledge test
[4] Visual part of the test for measuring deductive thinking
[5] Grade in secondary school leaving certificate
[6] B. Sc. Water Science or B. Sc. Chemistry

One can therefore see that the course of study has the highest impact on study success since the probability increases by a factor of roughly five if the value of the course of study changes by one unit from zero to one, which means from a student being enrolled in B.Sc. Water Science to a student being enrolled in B.Sc. Chemistry.
Only for the grade from the secondary school graduation certificate (*Abitur*) do lower values reflect higher abilities. So if the grade is one unit higher – which means worse – the probability for success shrinks. It will be only 0.618 times as high.

Other variables like subject interest and self-evaluation of capabilities in chemistry as well as gender do not significantly improve the model.
However, with the help of the regression model, it is possible to correctly assign 77.7 % of the students into the groups of successful and less successful students, respectively.

DISCUSSION

The best single predictor for success is pre-knowledge. This finding contradicts existing literature since the grade from the secondary school graduation certificate (*Abitur*) is usually thought of as the best single predictor for success. Attending a chemistry course in upper secondary school as a further aspect of pre-knowledge has not turned out to show any predictive strength. This could be possibly due to the fact that its influence depends on how far courses in school chemistry date back and if subject related work experience exists.
Concerning the ability in deductive thinking, the results only partly confirm the literature since only the visual part could be included in the regression model. However, this seems reasonable since studying chemistry requires the students to visualize concepts like atoms or orbitals and to think three-dimensionally. For subject interest and gender, ambiguous information can be found in the literature and, in this project, results show predictive strength for neither of them. The same can be found for self-evaluation.
In contrast to this, the course of study has a large impact on student success. This finding can be explained by the different structures of both courses of study. An important aspect is the fact that only B.Sc. Chemistry students have had a laboratory internship before taking the final exam at the end of the first semester. So B.Sc. Water Science students missed some important learning opportunities to deepen their knowledge in chemistry.

Outlook

The survey will be repeated at several German universities and also one in Finland in winter semester 2011/12. One can expect that students from different study locations will differ from each other.
With the help of the data, a general picture of freshmen in chemistry can be established and based on this, types of students can be identified with the help of cluster analysis. According to their initial qualifications those types can then be supported adequately to raise success rates in chemistry.

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PROFESSORS' PERSPECTIVES ON DROPOUT RATES IN UNDERGRADUATE PHYSICS COURSES

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Abstract: This paper reports an analysis of a focus group composed by Physics professors at the Federal University of Rio Grande do Sul, in Brazil. Professorial discourse was analyzed and contrasted to Bourdieu's sociology of education aiming to apprehend professorial standpoints concerning dropout rates in the Physics course, which are the highest in the country. Under the professors' perspective, students decide to dropout Physics undergraduate course mostly due to having formative deficiencies or not having the proper vocation. When they came to consider social variables, they perceive dropout as strictly related to economical distribution. In this sense, they believe inequity and drop out of the less prepared could be avoided by institutional actions as scholarship programs. On the other hand, when they describe pedagogical actions they could implement to reverse dropout, they assume responsibility for the problem. In this perspective, professors seemed to be not aware on the role the whole educational system plays in social and cultural reproduction of ruling classes. We believe that the access to Bourdieu's framework may lead professors to a sociological understanding of education and particularly of undergraduate Physics and, thus, to conceive more critical proposals for Physics teaching.

Keywords: Sociology of Education, Dropout Rates, Undergraduate Physics

BACKGROUND

Massive dropout in undergraduate Physics courses is a phenomenon that affects higher education institutions worldwide. This paper reports a research that constitutes a wider project aiming to investigate the reasons of dropout in Physics' undergraduate courses and its relation to quality of Physics teaching. An Institute of Physics (IP) under a federal Brazilian university was chosen as the case of study.

Indeed, Physics is amid the undergraduate courses that hold the highest dropout rates across this country (Silva Filho et al., 2007). Though dropout is a traditional theme in educational research, it has not yet been understood why are dropout rates higher in Physics' undergraduate courses and how these dropout rates are related to teaching.

In Brazil, recent changes in educational politics have brought dropout back to discussion in the national arena. In 2007, the government instituted a national program for higher education called Reuni[1]. This new national program has offered pecuniary benefits, scholarships, and professorial positions for the universities that committed to expand students' vacancy and to raise graduation rates. Together, these goals imply controlling dropout.

[1] Acronym that stands for "Program to support the restructuring and expansion of federal universities".

FRAMEWORK AND PURPOSE

The theoretical framework adopted for this paper is Pierre Bourdieu's Sociology of Education. Without the ambition of summarizing every contribution this author brings to the understanding of sociological issues in education and science education, it is possible to highlight several *theses* (Bourdieu, Passeron, 2009):

- **Competition in school.** Students do not compete under the same conditions in the educational system, not only because there are poor and rich families, but mostly because different families own different amounts of cultural capital.
- **Definition of cultural capital.** Cultural capital comprehend a variety of non-pecuniary features that make one's family more or less cultivated (such as scholar grades, mastery of cultivated language, information about the "scholar world", knowledge on sciences and other school subject matters).
- **The main role of school.** Despite being relatively independent of issues such as class struggle, the educational system has the main role of inculcating the culture of culturally ruling classes (eg., through its selection of curricular content matters and assessment methods);
- **Scholar contribution to social reproduction.** A straightforward implication of drawing its practices from the culture of culturally ruling classes in an heterogeneous society (concerning the distribution of cultural capital) is that school contributes to the greater success of students that stem from families that own more cultural capital due to the various advantages of being raised in a more "educated" environment.
- **Education and dissimulation of power.** It is fundamental for any teaching practice that aims to reach legitimacy that it conceives the relation of power lying beneath the definition of what should be taught and on which basis should students be assessed; The most successful is the school in conceiving the arbitrariness of the culture it inculcates, the most school legitimates this culture as dominant and their owners as culturally ruling class.

Hence, the condition of culturally ruling class is likely to be reproduced from one generation to another. Together, these *theses* express how school contributes to the social reproduction of culturally ruling classes and how class reproduction constitutes students' life in the educational system.

Considering the consistency of these *theses*, even if the same education is given to every student from the first day in school and even if assessment is "neutral", there will not be equal opportunities to every student as long as their families hold different amounts of cultural capital. Indeed, Bourdieu's sociology of education brings very critical perspective to the ideas that scholar success is related to individual gift, merit or vocation and to the idea that expanding the access to education is a solution to class struggle.

Given Bourdieu's framework, the purpose of this study is to analyze professorial discourse concerning dropout in a Brazilian undergraduate Physics course. For example, we will give attention to what causes they attribute to dropout, if they are social or individual and what would be the role of university to solve the problem.

METHODS

For this research, a focus group (Gatti, 2005), which is a technique for collecting verbal data from group discussions, was used. The discussion has involved 8 professors that were randomly chosen from faculty. There was also a mediator who was responsible to engender discussion through means of previously prepared open ended questions concerning teaching and dropout in undergraduate Physics course. The focus group was recorded in audio and video. The analytical device developed for this record was drawn from Bakhtin's social theory of language (1981, 1996) which is consistent to the theoretical grounds of Bourdieu's sociology of education (Hanks, 2008).

For Bakhtin and his colleagues, language is fundamentally a social phenomenon. He asserts that the *utterance* (complete speech act), in contrast to words and phrases, is the actual unity through means of which language is realized in human life (Bakhtin, 1996). As a matter of fact, the utterance has several distinguishable features such as *responsivity* and *directionality*. Each utterance is responsible for it agrees, contends or completes other utterances. Besides, every utterance is directional since it is likely to incite new utterances (the listener is another speaker) and it cannot escape the influences of anticipating these responses. This analytical device consists mainly of a procedure of analyzing responsive and directional relations between professors' speech acts.

The analytical device may be distinguished into three stages: (1) Narrative board; (2) Genetic diagrams; (3) Synthesis of the debate. The so called *narrative board* is essentially an ensemble of transcriptions and descriptions that represents verbal (and non verbal) actions taken in the focus group. Besides reducing the time necessary to fully transcribe the whole registers, this narrative board leads to a more straightforward understanding of what is on stake though the debate. From this narrative board, it was possible to observe the subthemes around which professors gravitate. For each of these themes, professors' utterances were organized in the so called *genetic diagrams*, which are representations of how research subject collectively develop new perspectives in a debate through means of agreeing, contending and expanding other's ideas. These discursive movements were respectively categorized under the bakhtinian concepts of ventriloquism, resistance and appropriation. Finally, from the genetic diagrams it was possible to observe, amid the various perspectives professors brought to the debate, that some standpoints are shared between (most) group members. These are presented as results of the analytical device.

ANALYSIS

As an example of how the analytical device has been implemented, we present here some excerpts of the narrative board along with its respective genetic diagram. As the narrative board involves both descriptions and transcriptions, it is important to highlight that literal transcriptions are always presented between quotation marks:

Mediator: The mediator, concerning undergraduate Physics courses, asks "What do you consider a Physics course of quality?".

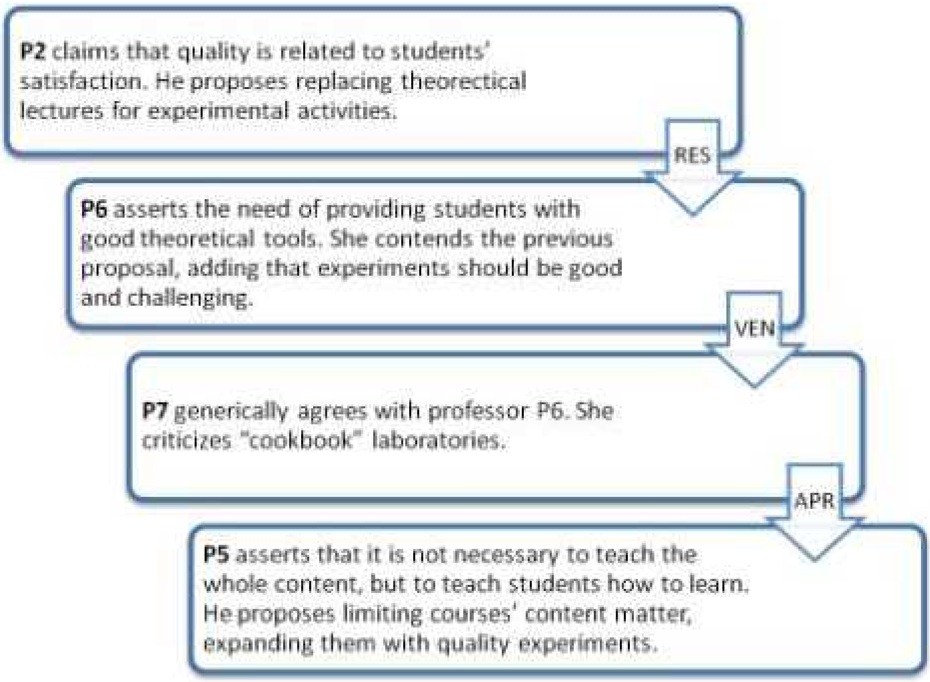
Prof_2: This professor claims that the quality of a Physics course is related to students' satisfaction. He says the course should be improved by means of planting interesting experiments. In reference to a specific discipline, which has gone through a large curricular reform some years ago, this professor declares that, in the period prior to the reform, "the student once a week, entered the laboratory, where there was a lot of experiments. It was not a single experiment. [...] Nowadays, students come to class and teachers spend 45 minutes lecturing! That would be an opportunity to improve this teaching, to make this more attractive to students, replacing the 45 minutes of lecturing for more experiments". Finally, this professor claims for radically replacing theoretical lectures for experimental activities.

Prof_6: This professor emphasizes that one needs to basically master theoretical foundations. She said "there's no way to learn physics only through experiments. From my point of view, one needs to organize their ideas. It is necessary to systematically teach concepts." Finally, she adds that the experiments must be good and challenging.

Prof_7: This professor says to agree to every word of Prof_6. She criticizes those "cookbook" laboratory activities. She repeats some of the claims make by Prof_6 in agreement.

Prof_5: This professor claims that Physics' curriculum does not need to embrace every content matter traditionally ascribed to undergraduate Physics course. On the other hand, curriculum must scaffold students to find their own way around. This professor says: "I think that we could be more selective on content matter and provide students with fewer but good bibliography, with interesting and advanced experiments with good theory. I have already noticed that there are things that I did not know by the end of my undergraduate course. However, as I've had a consistent education, I was capable of learning almost by myself. Then, I think that we need to limit content matter and add high quality experiments". Finally, this professor claims that a course of quality should teach students' how to learn.

Figure 1. Genetic diagram for the subtheme "experiments and the quality of Physics' undergraduate course".



Despite the differences between the perspectives every professor brings to the debate, it is possible to observe from this diagram how these perspectives are responsively related to each other. Hence, the genetic diagram is likely to clarify the relations (of ventriloquism, resistance and appropriation) between the various utterances that approach each subtheme. From this diagram, it is possible to observe that the last standpoint presented is an actual *synthesis* of conflictive perspectives brought by previous utterances. Finally, this analytical device was applied to every subtheme that arose in the debate. Results presented are the syntheses professors' standpoints.

RESULTS

From the analysis, it is possible to claim that professors' standpoints concerning dropout and quality in Physics teaching are the following:

- **Merit, vocation and formative deficiencies.** Under the professors' perspective, students decide to dropout Physics' undergraduate course mostly due to having formative deficiencies or not having the proper vocation.
- **Income distribution: THE social factor.** When professors approached social variables related to school success, they evoked income distribution, which has not been considered an educational issue since the formative deficiencies that poor students are more likely to have were considered to be surpassed only through means of scholarship programs.

- **Standpoint concerning REUNI.** REUNI is considered by professors an artificial and false solution to a very complex problem: the relation between student's class condition and access to and permanence in higher education.
- **The institutional role in controlling dropout.** Professors considered that, despite the lack of vocation and formative deficiencies students are likely to have, it is possible to slightly reduce dropout rates through means of giving more exciting classes, exploring interesting classical phenomena, new findings and technologies related to Physics.

It is important to highlight that professors' proposals did not take into account that giving the same education to socially different students means *not* to give them the same opportunities. After a long discussion about what are not their duties and responsibilities concerning students, professors approached what they actually could do about teaching so as to foster students' success and permanence in undergraduate Physics course. Under their perspective, the major contribution would be giving more exciting classes through means of exploring interesting classical phenomena or bringing to class new findings in the fields of Physics and its technologies.

CONCLUSIONS AND IMPLICATIONS

Professors frequently separated social issues (which were considered mainly economical) from the educational issues of lecturing and assessing students. Once this demarcation is established (once it is agreed that social issues, such as formative deficiencies ascribed to lack of economical capital, should not be of professorial concern) they feel comfortable to propose new pedagogical practices that might reduce dropout.

As it is possible to observe, this strategy of separating social from educational is immediately related to the merit, gift and vocation ideologies (for which Bourdieu brings critical perspective). More than a simple lack of awareness (Physics' professors not knowing Bourdieu's sociology), the separation social-educational protects the legitimacy of educational practices in the undergraduate Physics course from a more fundamental attack: from being accused of contributing to the reproduction of social class structure.

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DETERMINANTS AND FINALITIES IN THE CHOICE OF REVIEWING PROCEDURES: THE CASE OF RDST, A FRENCH SCIENCE EDUCATION RESEARCH JOURNAL

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Abstract: The merging of two French journals both publishing articles on research in science and technology education has made it necessary for them to compare the different reviewing procedures used by each. This comparison highlights two points: first, there are extrinsic and intrinsic determinants which affect the choice of reviewing modalities; and secondly, there are two finalities which could lead to the two journals converging, namely, the equity (fairness) or the equality of the different reviewing procedures.

Keywords: reviewing procedures ; journals ; science and technology education ; researcher ; community.

THE QUESTIONS RAISED BY THE MERGING OF THE TWO JOURNALS

Recherches en Didactique des Sciences et des Technologies is a very recent journal. The first issue was published in June 2010. This new francophone journal was the result of merging two French journals *Aster* and *Didaskalia*. These journals differed in several ways.

First, they did not have the same sections. *Aster* is a thematic journal, whereas *Didaskalia* is essentially non-thematic, even though some issues do contain articles on the same theme. *Aster* only contained research articles, whereas *Didaskalia* had other sections (such as points of view, reports on innovations, and reading notes). Thematic articles were reviewed at fixed dates, whereas the times at which non-thematic articles were reviewed could vary considerably.

Reviewers were not selected in the same way. The selection of the reviewers is an important phase of the reviewing procedure (Street et al, 1998). *Aster* systematically asked for two reviews, and a third if there was disagreement. However, *Didaskalia* always had three. For *Aster*, reviewers were selected by an editorial committee, which was made up of about 10 researchers from different French laboratories. One of the members of this committee was appointed specifically to supervise corrections to the article. For *Didaskalia*, it was the chief editor who selected the three reviewers.

Reviewing procedures also were different. For *Didaskalia*, it was the reviewers who studied the revised version of the article and decided whether the author had followed their recommendations. For *Aster*, it was the member of the committee who had been appointed to supervise the modifications who decided, together with the editorial committee, on the quality of the second version, and whether the author had followed the recommendations. For *Didaskalia*, the journals themselves were sent to the authors. For *Aster*, the committee member supervising the work wote a summary of the journal, and sent it to the author.

The grids designed for reviewing also differed. The *Aster* reviewers were sent a text describing the reviewing procedure, which provided some general indications (such as the intrinsic coherence, the logical organization of the arguments, validity of the method, theoretical references). The *Didaskalia* reviewers were sent a grid to be filled in with different sections (the presentation of the arguments, the theoretical framework, methodology, findings, discussion and conclusion, and the coherence between the different parts…).

To sum up, we can thus see that even if the two journals both published articles on research in science and technology education, eve, if they use the double blind peer review process (Baker, 2002), they did not use the same reviewing procedures. The new journal, RDST, kept all the sections from both *Didaskalia* and *Aster*. When the two journals merged, it was decided that, to begin with, the two reviewing systems would coexist, so that the first issue of RDST could be brought out on time. Afterwards, the editorial committee began studying ways in which the two reviewing procedures could converge. This discussion took place in a specific context.

THE RESEARCHERS' PROFESSIONAL MILIEU

The pressure of evaluation on university researchers was increasing considerably in France at the time of the merger of the two journals. The main criterion for evaluating research activity became publishing articles in international journals with an editorial board. Because of this, the need for all authors to have equal chances has become much greater.
The fact that it is now more important to consider this equality of opportunity has several consequences. For example it calls into question the idea that the complementarity of articles on a given theme (which is a criterion determined in the readers' interest) should be one of the criteria for choosing an article in the thematic section. It also calls into question the fact that the themes should be defined by the editorial committee alone. This also makes it necessary to harmonize reviewing procedures for the new journal, whether the articles are submitted for the thematic or the non-thematic sections.

HARMONIZING REVIEWING PROCEDURES

The ways in which harmonization has already been achieved

Two reviewers are selected for each article submitted to RDST. A third reviewer can be called on if there is any disagreement. This compromise has been established so that the procedure is not too far from international standards (3 reviewers), whilst taking into account the fact that there are fewer French-speaking reviewers than English-speaking ones.
The second way in which reviewing procedures have been harmonized concerns the supervision of modifications (the selection of reviewers, analysis of the reports, and expression of an opinion concerning possible publication of the article). While this work was done only by the chief editor for *Didaskalia*, it seemed preferable for there to be different points of view on these three points which are so crucial in reviewing.
For the non-thematic articles in RDST, supervision is carried out now by a chief editor who is in charge of the non-thematic section, and also by a member of the editorial committee. As for the thematic articles this task is given, as it was for *Aster*, to a member of the editorial committee who takes into account the opinions of all the members of the editorial committee. Thus, as far as these three crucial points are concerned, articles in the thematic and non-thematic sections are treated more fairly, but not in the same way.

The harmonizing yet to be done

For the time being, the tools used for reviewing are not at all similar. For the articles in the thematic section of RDST, the reviewing tool could be seen simply as a guide for reviewers. For the articles in the non-thematic section, there is a reviewing grid. These tools have totally different characteristics. The grid makes it easier to compare different reviews with each other. On the contrary, the guide is less clear, and leaves more room for reviewers' personal expression (Castro et al. 2003), which makes it harder to compare reviews.
But on the other hand, it is harder to adapt the grid to different types of article, (e.g., for qualitative or quantitative research) (Santiago-Delefosse, 2003). In other words, the guide is an egalitarian tool (as the same guide is used for any research article), but it may cause the reviews to be less equitable as they tend to be based on more personal criteria. However, the reviewing grid, which needs to be different in order for it to be adapted to different types of article, is not an egalitarian tool, but means that reviews are more equitable.
If new reviewers are to be trained, and also if the reviewing procedure is to be more transparent, it would seem preferable to give all the reviews to each reviewer. Although several members of the editorial committee agree to this, there is not enough time for it to be done. This systematic exchanging of reviews (Piolat et Vauclair, 2004) would only be possible if an electronic system were used for the submission and management of articles.
The principle of authors remaining anonymous is respected in both the thematic and non-thematic sections. If it is not possible to consider doing away with this (as is the case in "Education Research in Mathematics") because of the limited number of French-speaking reviewers, anonymity could be reinforced by asking authors to replace their names by the word 'author' in the quotations and bibliographical references.
Finally, the difference in the way reviewing is processed (either sending the writer the actual reviews or sending them a summary of the reviews written by a member of the editorial committee) has not yet been tackled, and the two systems co-exist. What is at stake here is the participation of the editorial committee in the reviewing procedure.

CONCLUSIONS

The reviewing modalities for RDST are evolving towards a more equitable treatment of research articles (thematic or not), yet without these being identical. The analysis that has been carried out in this article has enabled us to determine three extrinsic factors which influence the choice of reviewing procedures for RDST: the authors' professional milieu (in this case, the way their research is evaluated), the number of French-speaking researchers, and lastly, the readers). The times at which reviewing is done (strict deadlines for thematic articles whereas this is not the case for non-thematic articles) is a factor which is intrinsic to the way a review functions, and has a considerable impact on reviewing procedures. In order for reviewing procedures to become identical in this review, the times at which reviewing is carried out will have to be changed.

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GENDER DIFFERENCES IN 15 YEAR-OLDS' PERCEPTIONS OF PHYSICS, PHYSICS LESSONS AND PHYSICS TEACHERS.

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Abstract: This paper is based on quantitative survey findings of year 10 (15 year-old) students in 140 schools drawn from a longitudinal mixed methods project: Understanding Participation rates in post-16 Mathematics and Physics (UPMAP). The low number of students continuing with physics after compulsory education is a key concern amongst UK policy makers; the likelihood of girls going on to do physics post-16 is substantially less than that for boys despite there being no inherent gender difference in aptitude for physics. A literature review in conjunction with the team's expertise informed the development of a survey to explore students' attitudes towards various physics-related issues, support they received in physics learning as well as intentions to continue with physics post-16. Confirmatory factor analysis supported the various components of the survey, with some minor modifications. Analysis of the students' responses indicated the importance of teachers' encouragement in post-16 studies and further cemented our ideas about the importance of physics material gain motivation in inspiring students to continue on with physics after compulsory education.

Keywords: physics, gender, motivation, perceptions, teachers

INTRODUCTION

There are concerns around the gender gap in the uptake of post-16 physics in the UK as in a number of other countries in Europe and elsewhere; in addition, the gender gap is a continuous and established problem at secondary school, further education and higher education levels. Post-16 academic courses mostly take the form of Advanced Level (A-Level) in about two to four subjects with a great deal of student choice with examinations taken at age 18. In order to do physics at A-Level, students in the UK are typically required to get a high grade (A*, A or B) in the science or physics examinations they take at age 15 or 16. Attainment levels of boys and girls in physics/science at age 16 are quite similar with, if anything, girls doing slightly better (JCQ, 2011a). This demonstrates there is little if any inherent difference between boys and girls in their ability at physics.

In 2010, 51% of science General Certificate of Secondary Examination (GCSE) entries and 46% of these physics GCSE entries at age 16 were by girls. In contrast to this, the odds of girls going on to do physics post-16 are substantially less than that for boys, even after controlling for entry requirements into A-level, with the gender gap being wider for physics than for mathematics or any other science subject (JCQ, 2011b). The concerns with female participation rates in STEM (science, technology, engineering, mathematics) courses are also very much related to the high attrition rates of women at each post-16 stage as well as females in STEM careers (Blickenstaff, 2005). In the UK, there have been a number of national initiatives put in place to raise girls' engagement with physics by exposing them to educational activities that promote female-inclusive education such as 'Girls into Science and Technology' and 'Women into Science and Engineering'. These campaigns received much enthusiasm from schools (Smail et al., 1982; WISE, 2007). However, despite these initiatives, physics remains highly gendered. In response to this, the Institute of Physics commissioned a review with the hope that knowing what to do to boost girls' participation in physics A-Level would help resolve the problem with female recruitment into physics (Murphy and Whitelegg, 2006). However, the review was unable to come to firm conclusions about how to boost girls' participation in physics in post-compulsory education. Reasons put forward for the low participation of girls has ranged from: the low confidence and low science self-concept of girls, (Green et al. 2007); teacher influence and seeing the relevance of science (Reiss, 2004); lower levels of physics enjoyment and interest (Reid, 2003); and girls feeling STEM careers are for males (Lindsey et al., 1997).

CONTEXT AND METHODS

This paper is derived from the mixed methods longitudianal study Understanding Participation rates in post-16 Mathematics And Physics (UPMAP) study (2008-2011) which aims to identify factors that relate to students' intended choices with respect to physics and mathematics. This paper focuses on physics. We designed student questionnaires to include items from established psychological constructs alongside validated physics conceptual tasks. In total we had 5642 year 10 students who completed our surveys as learners of physics between October 2008 and April 2009. We also matched on data from the government such as prior attainment at age 11, gender, eligibility for free school meals (FSMs) and ethnicity.

The psychometric validity of our instruments were established via confirmatory factor analysis. Cronbach's alphas were used to assess the internal consistency of all constructs and these were found to have fair to high reliability (.6-.9). All of the items within each construct were scored so that a high score represents strong agreement (items were on a 6 point Likert scale), with scores above three indicate positive responses/agreements with statements. In this paper we explore students' perceptions, attitudes and motivations regarding physics lessons, physics teachers and physics itself. For such purposes we do not use the overall constructs but explore the importance of individual items within constructs. This focus was prompted by other UPMAP findings presented elsewhere suggesting there is more of a gender imbalance in perceptions, attitudes and motivations in physics than there is for mathematics. Previous work concluded that students' physics extrinsic motivation (i.e. students' intention to continue with physics because of the benefits they envisage for such things as job satisfaction and salary) was particularly important in encouraging year 10 students to continue with physics post-16 and the statistical significance of perceptions of teachers and lessons lost significance when controlling for students' physics extrinsic motivation.

RESULTS

For this paper the use of t-tests helped to gain an insight into the sorts of areas (perceptions of teachers, lessons and physics itself) that would be important for our work and inform the multi-level model analysis. The relationship between intention to participate and gender is consistent with general patterns of participation as reported in many studies. We found 13.3% of boys strongly agreed to continue with physics post-16 compared to 4.5% of girls while 17.7% of boys strongly disagreed to continue with physics compared to 24.9% of girls.

There were three areas that explored issues with teachers: encouragement, relationships and competence. Students on the whole had positive perceptions of their teacherse. Table 1 shows students were most positive about their teachers really wanting students to understand physics (mean of 4.93), followed by teachers believing that all students can learn physics (mean of 4.90). Students were least positive about teachers being interested in them as people (3.32) and physics teachers liking all students (mean 3.79). All of the items are summarised in Table 1 which includes the breakdown by gender and whether differences were statistically significant.

Table 1: Year 10 students' perceptions of physics teachers

Overall perceptions of physics teachers	All students			Boys			Girls		
Item	**N**	**M**	**SD**	**N**	**M**	**SD**	**N**	**M**	**SD**
**My teacher thinks that I should continue with physics post-16	2607	4.06	1.6	1253	4.33	1.49	1343	3.79	1.65
**I like my physics teacher	4878	4.02	1.54	2234	4.07	1.54	2625	3.99	1.51
**My teacher has high expectations of what students can learn	4448	4.82	1.07	2037	4.90	1.07	2395	4.76	1.06
My teacher believes that all students can learn physics	4423	4.90	1.03	2032	4.91	1.05	2373	4.89	1.01
My teacher wants us to really understand physics	4555	4.93	1.02	2088	4.96	1.04	2451	4.90	1.01
My physics teacher sets us homework	4715	4.79	1.24	2146	4.80	1.25	2552	4.77	1.23
My teacher believes that mistakes are OK when learning	4420	4.59	1.24	2048	4.57	1.27	2356	4.61	1.25
**My teacher is interested in me as a person	3704	3.32	1.56	1698	3.41	1.58	1990	3.23	1.53
My teacher seems to like all the students	4319	3.79	1.57	1969	3.79	1.59	2336	3.79	1.55
My teacher is interested in what students think	4434	4.26	1.36	2021	4.30	1.37	2396	4.23	1.34
My teacher only cares about students who get good marks	4347	4.38	1.44	1968	4.35	1.5	2363	4.41	1.4
My teacher lets us get away with not doing homework	4526	4.56	1.39	2061	4.56	1.44	2447	4.56	1.35
My teacher treats all students the same regardless of their ability	4439	4.36	1.39	2041	4.37	1.41	2382	4.35	1.37
**My teacher is good at explaining physics	4630	4.28	1.41	2119	4.47	1.36	2494	4.12	1.43
*My teacher marks and returns homework quickly	4346	4.05	1.47	1984	4.12	1.45	2344	3.99	1.49

Notes: ** significant at .001; * significant at .01; N (number); M (mean); SD (standard deviation); comparisons between girls and boys.

Teachers' encouragement: Boys were more likely to give positive responses about feeling their teachers: encouraged them to continue with physics post-16 ($t=8.085$, $p<.001$); had high expectations of what students can learn ($t=4.353$, $p<.001$).
Personal relationships with physics teachers: Boys were more likely to report their physics teachers were in interested in them as people ($t=3.426$, $p<.001$).
Competence of physics teachers: Boys were more likely to report that their physics teachers: were good at explaining physics ($t=8.328$, $p<.001$); marked and returned homework quickly ($t=2.918$, $p<.01$).

Students' perceptions of physics lessons

There were four areas that explored issues with physics lessons: laboratory and practical work; learning physics concepts; enjoyment of physics lessons; self concept in physics as impacted by physics lessons. All of the items are summarised in Table 2 which includes the breakdown by gender and whether differences were statistically significant.

Table 2: Year 10 students' perceptions of physics lessons

	All students			Boys			Girls		
Item	**N**	**M**	**SD**	**N**	**M**	**SD**	**N**	**M**	**SD**
**I look forward to physics classes	4964	3.13	1.44	2276	3.39	1.46	2669	2.90	1.38
**My teacher explains how a physics idea can be applied to a number of different situations	4893	3.82	1.39	2248	4.03	1.37	2627	3.65	1.37
**I have the opportunity to discuss ideas about physics	4921	3.87	1.41	2260	4.03	1.39	2643	3.74	1.40
**I do well in physics tests	4926	3.82	1.34	2263	4.15	1.28	2645	3.53	1.32
**I enjoy my physics lessons	4945	3.43	1.47	2267	3.72	1.45	2661	3.18	1.43
**I can see the relevance of physics lessons	4903	3.94	1.39	2246	4.17	1.35	2640	3.74	1.38
**When I am doing physics, I always know what I am doing	4958	3.19	1.31	2270	3.57	1.30	2669	2.87	1.23
When I am doing physics, I am learning new skills	4944	4.00	1.25	2266	4.16	1.25	2660	3.85	1.23
*When I am doing physics, I am not bored	4940	3.18	1.53	2260	3.42	1.56	2661	2.98	1.48
*When I am doing physics, I pay attention	4959	3.82	1.31	2270	4.00	1.31	2672	3.67	1.29

When I am doing physics, I don't get upset	4927	5.02	1.38	2254	5.07	1.45	2655	4.98	1.32
**When I am doing physics, I don't daydream	4940	3.26	1.59	2262	3.49	1.65	2659	3.07	1.50
**In my lessons, we do investigations to test our own ideas	4553	3.46	1.48	2081	3.52	1.50	2456	3.41	1.46
**I look forward to spending time in the lab to do practical investigations	4585	4.11	1.59	2093	4.44	1.50	2475	3.82	1.61
**Thinking about your physics lessons, how do you feel you compare with the others in your group?	4867	3.32	1.09	2233	3.63	1.08	2616	3.05	1.03

Notes: ** significant at .001; * significant at .01; N (number); M (mean); SD (standard deviation); comparisons between girls and boys.

Descriptive statistics indicated that students on the whole had positive perceptions of their physics lessons but with some areas of concern. Students were most positive about not being upset when doing physics (mean of 5.02), followed by looking forward to spending time in the laboratory doing experiments (mean of 4.11). Students were least positive about looking forward to physics classes (3.13) and not being bored when doing physics (mean 3.18), an indication that students were showing signs of being bored, closely followed by students reporting that they always knew what they were doing when doing physics (3.19). For some of the items in Table 2 there were statistically significant differences in responses between boys and girls, with boys reporting more positively about questions around physics lessons. The largest significant difference in responses between boys and girls was 'When I am doing physics I always know what I am doing' (.69 mean difference), followed by 'I do well in physics tests' with a mean difference of .62.

Laboratory and practical work: Boys were more positive about: looking forward to spending time in the laboratory doing practical investigations ($t=13.236$, $p<.001$); having the opportunities to do investigations to test out their own ideas ($t=2.435$, $p<.001$).
Learning physics concepts: Boys were: more likely to report that their teacher explained how physics ideas can be applied to a number of different situations ($t=9.630$, $p<.001$); more positive about having the opportunity to discuss their ideas about physics ($t=7.110$, $p<.001$); more likely to report seeing the relevance of physics lessons ($t=11.050$, $p<.001$).
Enjoyment of physics lessons: Boys were more likely to report: looking forward to their physics classes ($t=12.334$, $p<.001$); enjoying their physics lessons ($t=13.154$, $p<.001$).
Self concept in physics as impacted by physics lessons: Boys were: more positive about doing well in their physics tests ($t=16.670$, $p<.001$); more likely to report doing better in their physics lessons than their peers ($t=19.102$, $p<.001$).

Students' perceptions of physics

There were six areas that explored perceptions of physics: laboratory and practical work; usefulness of physics; self concept in physics; liking of physics; physics and social skills; and doing physics. Descriptive statistics (Table 3) indicated that students' responses about physics were generally positive though there were some aspects of physics that students were not positive about / did not agree with. Students were most positive about / in agreement with 'To be good at physics, you need to work hard' (mean 4.66) and least positive about 'Being good at physics makes you popular' (mean 1.95).

Table 3: Year 10 students' perceptions of physics

Perceptions of lessons	**All students**			**Boys**			**Girls**		
Item	**N**	**M**	**SD**	**N**	**M**	**SD**	**N**	**M**	**SD**
**I think physics is a useful subject	4988	4.24	1.24	2292	4.43	1.24	2676	4.08	1.21
**I think physics is an interesting subject	4904	3.67	1.45	2246	3.99	1.45	2641	3.40	1.40
**I think physics will help me in the job I want to do in the future	4868	3.05	1.59	2235	3.35	1.65	2615	2.80	1.50
**I am good at physics	4880	3.84	1.31	2254	4.23	1.21	2606	3.49	1.28
**People who are good at physics get well-paid jobs	3820	4.17	1.18	1776	4.28	1.1	2028	4.07	1.17

Being good at physics impresses people	4187	3.36	1.41	1889	3.40	1.44	2287	3.33	1.38
**Physics teaches you to think logically	4400	4.05	1.25	2020	4.15	1.29	2364	3.96	1.21
**Physics helps you in solving everyday problems	4484	3.33	1.30	2062	3.47	1.37	2409	3.21	1.28
Physics improves your social skills	4361	2.20	1.21	1965	2.27	1.30	2382	2.13	1.12
**To be good at physics, you need to be creative	4397	2.57	1.31	1987	2.84	1.41	2398	2.35	1.17
To be good at physics, you need to work hard	4712	4.66	1.22	2138	4.69	1.22	2560	4.64	1.22
**Being good at physics makes you popular	4225	1.95	1.17	1909	2.08	1.23	2305	1.84	1.06
**Physics is interesting	4920	3.60	1.53	2251	3.92	1.53	2653	3.32	1.48
**Physics is important in making new discoveries	4576	4.57	1.22	2110	4.67	1.21	2450	4.48	1.23
**Those who are good at physics are clever	4435	4.06	1.40	2023	4.14	1.38	2398	4.00	1.41
**These days, everybody needs to know some physics	4498	3.95	1.27	2062	3.99	1.31	2422	3.91	1.23
**It's interesting to find out about the laws that explain different phenomena	3719	3.90	1.45	1777	4.12	1.41	1934	3.70	1.46
**There is only one right way to solve any physics problem	3489	4.23	1.38	1655	4.17	1.46	1824	4.28	1.29
**I don't need help with physics	4900	3.37	1.52	2243	3.82	1.53	2639	2.99	1.40

Notes: ** significant at .001; * significant at .01; N (number); M (mean); SD (standard deviation) ; comparisons between girls and boys.

For some of the items in Table 3 there were statistically significant differences in responses between boys and girls, with boys reporting more positively about questions around physics. *Usefulness of physics:* Boys were more likely to report that: physics is a useful subject ($t=10.021$, $p<.001$); physics is more likely to to help them get into jobs they want to do in the future ($t=12.196$, $p<.001$); physics teaches individuals to think logically ($t=5.270$, $p<.001$); physics helps individuals to solve everyday problems ($t=6.697$, $p<.001$); physics is important in making new discoveries ($t=5.243$, $p<.001$); people who are good at physics get well paid jobs, ($t=5.655$, $p<.001$).
Self concept in physics: Boys were more likely to report that they: are good at physics ($t=20.625$, $p<.001$); do not need help with physics, ($t=19.821$, $p<.001$).
Liking of physics: Boys were more likely to report that: physics was an interesting subject ($t=14.372$, $p<.001$); they found physics interesting ($t=13.753$, $p<.001$); these days everyone needs to know some physics ($t=2.102$, $p<.05$); it is interesting to find out about the laws of physics that explain different phenomena ($t=8.915$, $p<.001$); physics is a useful subject ($t=10.021$, $p<.001$).
Physics and social skills: Boys were more likely to report that physics: improves individuals social skills ($t=3.682$, $p<.001$); makes individuals popular ($t=6.671$, $p<.001$).
Doing physics: Boys were more likely to report that: to be good at physics individuals need to be creative ($t=12.508$, $p<.001$); those who were good at physics were those who were clever, ($t=3.379$, $p<.001$). Interestingly, girls were more likely to report that there is only one right way to solve any physics problem ($t= -2.275$, $p<.01$), which if read carefully is in line with many of the findings around physics. Girls, as a group, feel disengaged with physics and this may be related to the way it is taught, with girls not feeling there are a range of ways to learn physics.

Multi-level models that explore the importance of students' perceptions in intended post-16 physics participation

Multi-level models were run in a series of stages which had particular theoretical relevance and in this paper we will present the final, best fit model (model 6) rather than models run prior to this (Table 4), though will mention in passing results emanating from earlier models that became redundant, in order to elucidate issues around how extrinsic material gain motivation (i.e. students' intention to continue with physics because of the benefits they envisage for such things as job satisfaction and salary) is important in explaining intended participation.

We first established a variance components model, which indicated that 6% of the variance in intention to participate scores was attributable to differences between schools whereas the vast majority of the variance in scores was attributable to differences between students. In model 1 we differentiated between students' year groups, so that we could compare the impact of gender (when introduced in model 2). The younger students (year 8, aged 12-13) were statistically significantly more likely to express an intention to continue with physics in post-compulsory education. Model 2 showed that the gender gap between girls and boys in their intentions to continue with physics post-16 were larger for year 10 students than for year 8 students. Such differences continued after adjusting for students' age 11 (key stage 2) prior attainment scores and current conceptual ability in physics (in model 3), suggesting that even after controlling for students' attainment levels, boys were more likely than girls to express an intention to continue with physics post-16.

In model 4, we introduced items that explored students' perceptions of their physics teachers and found that even after adjusting for prior attainment, age and gender the following items were significant: 'my teacher thinks I should continue to study physics after the age of sixteen', 'my physics teacher is good at explaining physics' and 'my physics teacher is interested in me as a person'. However, in the final model it was only the last of these items that remained significant after controlling for physics extrinsic material gain motivation. In model 5, we introduced items that tapped into perceptions of physics lessons. Enjoyment of physics lessons was the only item that had a significant influence on intended participation in the final model. Though we saw the influence of prior attainment lose significance, we note that the influence of gender remained important in the final model and that this influence was stronger in the year 10 cohort than in the year 8 cohort.

In model 6 (our final model) we explored the influence of the items that measured students' perceptions of physics and within this grouping the following items were found to have a significant influence on intended participation: 'I think physics is a useful subject'; 'I think physics is an interesting subject'; 'I think physics will help me in the job I want to do in the future'; 'I am good at physics'; and 'I don't need help with physics'. Table 4 shows that the majority of the items that explain intended participation are those to do with perceptions of physics rather than ones to do with perceptions of teachers or of lessons (because at this point the great majority of items that were significant in previous models lost significance or had a weaker influence). Although teachers' encouragement of students continuing with physics post-16 was an important predictor, as were items to do with self-concept and enjoyment of lessons, the influence of such measures was still not as strong as extrinsic material gain motivation. This indicates that while other factors are also important in shaping students' intentions to participate in physics post-16, physics extrinsic material gain motivation is the most important.

Table 4: Factors that shape intended participation amongst year 8 and year 10 students

Fixed effects	Coefficient	Standard error
Intercept	3.514	0.03278
Year 8 or 10	-0.28	0.03
Gender (female)	-0.13	0.00
My teacher thinks that I should continue with physics beyond my GCSEs.	0.11	0.01
I enjoy my physics lessons.	0.09	0.01
I think physics is a useful subject.	0.20	0.02
I think physics is an interesting subject.	0.14	0.02
I think physics will help me in the job I want to do in the future.	0.40	0.01

I am good at physics.	0.08	0.02
I need help with physics.	0.02	0.01
Random effects variance	0.269	0.056

CONCLUSIONS AND IMPLICATIONS

An item analysis rather than a construct analysis found support for the importance of extrinsic material gain motivation on intended participation in physics. In addition the analysis showed that amongst the perception of teachers items, teachers' belief in individual students continuing with physics post-16 is the most strongly associated item with intended participation. This item was a significant predictor in the final multi-level model even after controlling for physics extrinsic motivation. Other items within the 'perceptions of teachers' cluster that were somewhat important in intended participation were teachers being good at explaining physics and teachers taking an interest in students as people (for both boys and girls). The multi-level findings indicate that enjoyment of physics lessons (intrinsic value), seeing the relevance of physics (extrinsic value) and students feeling they do well in physics are related to intended participation. There is a strong influence of gender on intended physics participation and the gender gap in perceptions of teachers, lessons and physics increases as students get older. These findings point toward recommendations to continue to promote and fund interventions, initiatives and practices that take into account of and attempt to reduce gender differences.

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SELF-DETERMINATION AS KEY FOR A CROSS-CULTURAL COMPUTER-BASED LEARNING ENVIRONMENT

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Abstract: The overall aim of the investigation at hand is the insight into educational cross-cultural factors for implementing a specific computer-based learning environment (CBLE) abroad. In a previous study, this CBLE concerning optics for German science classes at secondary school level was developed and evaluated. For the cross-cultural explorative research, four Colombian schools were contacted. Their conditions (curriculum, computers available), the motivation of students working with the CBLE (n=284 divided in nine 8^{th}-10^{th} grade classes) and videotaped learning processes of some of these students (n=18) working with one unit have been studied. A statistical analysis of questionnaires dealing with external conditions and motivational issues has been conducted. A content analysis of videotapes, transcripts and answers to the exercises of the analyzed unit has been accomplished. Results show that students mostly worked with high discipline and against the intentions very teacher-centred. When talking, students express themselves abruptly. Conceptual contents were used less precisely. It has been interpreted that self-determination could be a crucial criterion for the successful adaptation of the CBLE over three different levels: (1) Colombian teachers didn't adapt the experimental CBLE to their curriculum, which thwarted the targeted work in classroom; (2) the CBLE itself demanded more autonomy than students experienced; and (3) if students were asked to determine their learning processes themselves, they had to verbalize their thoughts as much as possible. Therefore this explorative study shows that states of self-determination at these three levels should be considered prior to cross-cultural implementations of CBLEs.

Keywords: Self-determination, Cross-cultural, Computer-based, Motivation, Learning

INTRODUCTION

In times of commercial globalization, educational systems also experience a pressure to be universalized and harmonized (e.g. Sjøberg 2007). Some ethnographical studies have thrown some light on cultural diversity in science education (e. g., Mueller & Tippins 2010). Teachers are due to accommodate global aims of science instruction to the local situations and necessities, especially because of the rising opportunities of the information and communication technology (e.g., Parrish & Linder-VanBerschot 2010). For instance, Oliveira et al. have studied the adaptation and implementation of an US-American learning environment to the conditions of other countries made by local teachers (Oliveira et al. 2009). Some authors highlighted the challenges of increasing sensitivity to cultural differences, people's values and lifestyles (e.g., Rogers et al. 2007).

The present contribution is dedicated to possible indicators for the "culture-equitableness" of a computer-based learning environment. This learning environment was developed in Germany for science classes at secondary school level (Schnirch 2006). It deals with light phenomena (physics) and the perception of the human eye (biology) integrating real experiments. The overall question of the present study was the use of this computer-based learning platform in a different cultural context. For it, an explorative research has been conducted in Colombian schools, in which the *previous external conditions* of schools and science classes have been assessed, the *motivation* of students while working with the learning environment has been analyzed, and *learning processes* concerning one unit of the CBLE have been examined. These three levels are separately represented in the following chapters.

RATIONALE

The three introduced levels for the cross-cultural explorative investigation are based on different theoretical frameworks explained in brief as follows.

Concerning the Previous External Conditions of the Investigated Schools

Over the past years the Colombian Ministry of Education has developed a so called Revolution of Education, which is focussed on the evolution of educational covertures considering efficiency, coordination of territorial educational offers and the active implication of population (M.E. 2002, M.E. 2008b). Amongst others, pedagogical standards concerning competencies for science (and social) education have been represented as guide for local adaptation (M.E. 2004a, 2004b). Moreover, innovation and use of Information and Communication Technology (ICT) are part of a big programme that pursues updating of computer-labs, expansion of internet-connectivity, vocational training of teachers and establishment of an internet network containing multiple teaching and learning materials[1].

Self-Determination Theory of Motivation

Deci and Ryan (1985) developed the Self-Determination Theory of motivation (SDT), which declares that every form of human motivation goes back to the endeavour to fulfil basic and innate needs. Those basic needs are autonomy, competence feedback, and relatedness. By internalizing extrinsic motivation through self-determined motivation one can reach intrinsic motivation. This process is called internalization and refers to people’s “taking in” a value or regulation. As people internalize regulations and assimilate to the self, they experience greater autonomy in action. The extrinsic motivation is thereby divided in four different levels of regulation (external, introjected, identified and integrated) that defined the process of internalization of a given activity towards intrinsic motivated behaviours.

Linguistic framework for Analysis of Learning Processes in Verbalizations

The theoretical approach of the present study in terms of learning is based on constructivism (e.g. Glasersfeld 1995, Vygotskij 1978) and Luhmann’s social systemic theory (Luhmann 1984). A detailed theoretical analysis will be given in future publications. The present contribution deals with the analysis of verbalizations of students during autonomous work in science classes. For it, Bloor’s linguistic Strong Programme has been considered (Bloor 1980). Herein language is divided into three domains: (1) Physiological, psychological, biological intuitions and skills, (2) social interests and needs, and (3) language-games and meaning. The first domain is supposed to be related to the grammatical and syntactical structure of language (Chomsky 1972). Within this domain in the present investigation, deductive content analysis using Halliday’s Systemic Functional Grammar (Halliday 2004) has been conducted. The second and third domain are linked to interpretation of wording and context (Kertész 2004). These have been inductive qualitative analyzed (category-based) in the present explorative research.

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[1] http://www.colombiaaprende.edu.co/html/home/1592/channel.html

RESEARCH METHODS

A brief introduction with respect to the research design precedes the research methods for better understanding of the whole research study.

Chronological Research Design

The data for the three analytical fields of the investigation (external conditions, motivation and learning) have been gained during two stays in Colombia (two weeks in October 2007 and four weeks in February-March 2008). The conditions within these schools with respect to science classes and to the use of computers have been asked by means of a written survey during the first stay. As consequence of this, minor changes were included in the units of the computer-based learning environment and the integrated real materials for its adoption in Colombian schools. In February 2008 the learning platform was firstly introduced to teachers. After that, students worked with the computer-based tasks autonomously (approx. one hour). The nine participating classes (8^{th}-10^{th} grades) are three classes of a mono-educative school and two classes in each of the other three co-educative schools. Finally, one day after the computer-based work, the experiences made were debriefed with the whole class.

Method for the Analysis of Previous External Conditions

The conditions mostly regarding the personal appreciation of the use of ICT at home and school were asked by means of an explorative written survey. N = 16 teachers and n = 222 students were reached. Questions for teachers were focussed on the personal use of ICT and the way of implementation in science classes (19 closed items and 8 open questions). Besides, a personal estimation about the means of ICT in science classes (21 closed and 3 open items) and on students' interest in science (2 open items). Finally, personal interest of teachers in ICT and the investigation were consulted (7 closed items). Content and frequency analysis of these questionnaires have been conducted.

Method for the Study of Motivation

During the debriefing of the unit, students filled in a questionnaire related principally to motivation while interacting with the learning environment during the second stay. A total of n = 284 students (206 girls and 78 boys) completely filled in the questionnaire: A multidimensional measurement device (McAuley et al. 1989) that has been developed and evaluated at the University of Rochester intending to assess participants' experience related to a target activity in laboratory experiments. The multidimensional measurement device, called "Intrinsic Motivation Inventory"[2] (IMI), contains a variable number of items according to the requirements, and comprehends seven subscales that rest upon the Self-Determination Theory of motivation (SDT). These subscales are "interest/enjoyment", "perceived competence", "perceived choice", "social relatedness", "value/usefulness", "pressure/tension", and "effort/importance". An additional open question with reference to the acceptance of the learning environment was included.

In the previous study in Germany (Schnirch 2006) the IMI-questionnaire was already adopted and contained 41 items using a 5.likert-scale (from "strongly agree" to "strongly disagree"). Therein, the factor loading was proven by means of reliability analysis. Subscales were reliable and could be fitted to normal distributions. The Spanish version of the questionnaire

[2] http://www.psych.rochester.edu/SDT/measures/IMI_description.php

was translated using the German one. The comprehensibility of the items was checked by experts.

Method for the Analysis of Learning Processes

N =18 students (4 girls', 1 boys' and 1 mixed dyads; 1 boys', 1 girls' triad) working on one unit of the learning environment were video-recorded. The unit concerns the "red-eyes'-phenomenon" and the parts and functions of the human eye. At the end of each exercise, students had to write down their conclusions into a textbox inside the program. These conclusions were saved for research.

Concerning the analysis, first of all, recorded activities of students have been categorized. From this first examination, scenes containing conceptual verbalizations have been selected (approx. 40 minutes of 8 hours of videotapes) for further detailed analyses. Transcripts of these verbalizations have been compiled and studied in two steps (first two steps below). The written responses by students after each exercise are the database for the third step of the investigation. Hence, the three domains introduced in the rationale have been analysed separately:

- 1st step: Research on language intuitions by means of a deductive, category-based analysis of verbalizations, which are related to the contents shown in the learning environment. A category system was developed based on the Systemic Functional Grammar (SFG). Therein the grammatical function of verbal, nominal and circumstantial phrases and words within utterances and conjunctions linking complex clauses has been examined.
- 2nd step: Research on interest and intentions by means of an inductive, category-based analysis of the immediate actions, which initiate the verbalizations concerning the contents. Therein each content-related verbalization was supposed to be initiated by a certain event (e.g., question, teacher, other students). Moreover, the initiative of the action (learning environment, teacher, student) and the interpersonal behaviour (individual, collective) have been recognized.
- 3rd step: Research on meaning of written answers using an inductive, category-based analysis. The conceptual topics included in the final answers of students have been categorized and put into conceptual generic groups.

RESULTS

Concerning the Previous External Conditions

The analysis of data collected during the first stay in the Colombian schools yielded that the implementation of the German learning environment in science classes could be conducted. Schools owned computer-labs (one or two labs à approx. 20 PCs for the whole school). In two of four schools equipments needed updating. On the one hand, teachers moderately used ICT for preparing their science classes. Some of them didn't implement ICT in science classes. Nevertheless, almost all teachers asked shared the opinion that teaching with ICT needs an adapted teaching methodology. They also highlighted the potentiality of ICT for educational purposes. Concerning the personal use of ICT, teachers draw on them for writing documents and virtual networking. A training session for teachers previous to the work with students was added to the research design. Nevertheless, teachers did not feel confident enough after this training session to implement the unit by themselves.

Concerning Motivational Aspects

The means of almost all subscales of the IMI measurement device were very high. From this point of view it could be concluded that students were intrinsically motivated while working with the learning environment. That is why small differences of means have been closely examined. The subscales “interest/enjoyment” and “value/usefulness” got the highest means. In contrast, “perceived choice”, “effort/importance” and “pressure/tension” showed slight differences to the other four subscales. An in-depth analysis of the data leads to the assumption that the answers were not normally distributed for which reason they presented high skewness. Moreover, it has been noticed that the wording of questions played an important role in answering. Distributions of negative worded items differed considerably from positive worded. The study of these features has been presented elsewhere (Rueda & Welzel-Breuer 2009).

Concerning Learning Processes

The recorded verbalizations of students while working with the unit that deals with the “red-eyes’-phenomenon” and the constitution of the human eye have been studied in two steps. The third step concerned the content analysis of written conclusions of students.

- 1st step about grammatical analysis: In most of the cases students talked very abruptly without following a marked argumentation pattern. They expressed their ideas in single word groups or incomplete clauses. By means of a category-system based on SFG the grammatical content of verbalizations of students has been examined. Determinative nominal groups (e.g., single nouns) and material verbs (e.g. describing what happened) were the most frequent components of verbalizations. Moreover, students spoke more actively when the exercise had to do with assumptions about circumstances or events (e.g., the “red-eyes’-phenomenon” or the similarities of humans’ eyes to animals’ eyes). Although students found information about specific terms (e.g. properties of light, or parts and functions of the eye), they did infrequently construct verbal relations with them (e.g. “the light is very fast”). Complex clauses (e.g., using conjunctions) have been detected in few cases, in which only contingency (e.g., “if… then…”) and causality (e.g. “because…”) were detected. Few analogies (e.g., “this is like…”) or relations to what occurred (e.g., “where…”, “when…”) were identified. These shortly presented results can be summarize such that students spoke mostly about concrete events (single unspecific nouns and material verbs) without refining their discourses. They seldom showed a need for expressing conceptualization or interconnected ideas.
- 2nd step about contextual analysis: In the second step, it has been sought a reason for behaviours presented in the first step. The initiator of the content-related verbalizations was examined (e.g., interest of students, teachers, or learning environment). The behaviour of the 8 recorded groups before talking has been coded using three categories: Initiator (e.g., task, materials, students’ interests), initiative (e.g., learning environment, teacher, students) and interpersonal behaviour (individual, collective). It could be determined a spectrum of actions presenting two extremes: extrinsic-driven, intrinsic-driven behaviour. In addition, the behaviour of individuals had an impact on co-operative work of groups. Students who worked very interested did so mostly alone. Students who were not very interested stayed together. In between, two more levels have been distinguished: First, when students in groups worked extrinsic-driven, doing the tasks individually on their own (“self-awareness”); and second, when students were sometimes interested in the exercises and worked always together (“perception of common value”). Recapitulating, four levels have been detected (external control, self-awareness, perception of value, internal control), which could be associated to the four levels of regulation within the Self-Determination Theory of motivation introduced in the rationale.
- 3rd step about semantic analysis: The written conclusions of students for each exercise of the video-recorded unit have been explored using content analysis. Inductive-driven

systems of categories for each exercise has been built and interpreted. The students invested more time in writing answers about assumptions. Summarizing, a working process can be recognized in the semantic category-based analysis of the written answers. Two of eight groups properly connected the parts and functions of human's eyes with the "red-eyes'-phenomenon". The other six groups didn't realize this connection or didn't write enough correct arguments. Therefore, it can be interpreted that these six groups didn't take control of their own learning processes.

CONCLUSIONS AND IMPLICATIONS

An explorative research of the implementation in Colombian schools of a German computer-based learning environment that includes real experiments has been conducted in small scale. The analysis has been divided in three parts: a macro-level (external conditions), a meso-level (motivation of students) and a micro-level (learning of students). One overall conclusion can be stressed from all three levels, namely, the importance of self-determination.

Although the heads of schools and teachers were very open-minded and helpful with regard to the implementation of the study, mainly teachers didn't integrate the unit in their science curriculum (in spite of consultation and arrangement before the second stay and training before adoption). This fact undermined self-determination and participation of teachers during the class-work and decreased concrete motivational value of the unit for students. Only slight differences in the results concerning motivation give reason to the interpretation that they couldn't work freely enough unfolding their self-determination during the autonomous learning. The role of the teacher is therefore to properly introduce such a computer-based unit encouraging autonomy of students. This interpretation has to be proven in further research.

Concerning learning processes, a three-step method has been conducted. In each of these steps, produced text (verbal and written) has been analysed differently (grammatically, contextually and semantically). Detected imprecise and abrupt expressions could mirror shortcomings within the configuration of the learning environment (and especially inside the investigated unit). But, again, some evidence has been presented which target a lack of self-determination in six of eight students' groups. It has to be kept in mind, that the learning has been studied in only one unit and that collective learning by means of interactions or further actions has not been considered. Exclusively learning processes related to the conceptual contents of the unit have been examined.

In summary, the results obtained are plausible and coherent to other science educational research. The integration of innovative teaching methods into concrete school and curriculum conditions is considered under professional development, especially the fact that teachers have to become more aware of their practice (e.g., Taitelbaum et al. 2008; Dass & Yager 2009). Besides, students' learning processes in autonomous settings accentuate the self-regulation component of learning (e.g., Pintrich 1999). With respect to the conceptualization within the analyzed unit, students could have needed more scaffolding in order to verbalize and their own experiences. In fact, these issues are included in other units of the learning environment (that recorded students couldn't experience during the planed implementation). Moreover, the role of teacher in final debriefing phases is essential.

Finally, it should be highlighted that the methodological integration of those environments has to be actively done by teachers themselves. Concerning the use of innovative instructional settings, researchers and teachers (and even principals) must work together during the design of research. Additionally, a previous analysis of autonomous learning skills of students must not be overlooked. A proper level of self-determination of the targeted populations (school, teachers and students) is hereby remarked as the key for a successful implementation of a

CBLE over the three investigated levels (external conditions, motivation and learning processes).

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ANALYSIS OF SCIENCE TEXTBOOKS FOR A-LEVELS IN THE UK: ISSUES OF GENDER REPRESENTATION

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Abstract: Curriculum materials play a role in making a discipline relevant and attractive to students and encouraging their involvement. This study has the objective of determining the gender balance in selected chemistry, physics and biology textbooks for A-levels in the UK. An exploratory study is conducted by analysing both the illustrations and the text for six textbooks adopting context-based approaches. Drawings and photographs were categorized whether they depicted males, females or both. Names appearing in the text were classified according to gender. Results revealed that males are heavily over-represented in the illustrations and 87% of the names appeared in the text belong to males. The message delivered through the more frequent depiction of males, even not intended, may be received by students as science is for all students in school but preserves males more.

Keywords: Textbook analysis, Gender representation, A-levels

INTRODUCTION

For the last two decades, science education has received an exceptional attention from stakeholders as a field of significant potential impact on a nation's success. Many efforts have been made to improve science teaching and learning in non-customary ways. Science education reform initiatives in the USA have targeted scientific literacy through inquiry experiences and skills "for all" (American Association for the Advancement of Science [AAAS], 1990, 1993; National Research Council [NRC], 1996). Many other countries directly or indirectly have shared the notion of educating all of their citizens and teaching science as inquiry as a major part of their educational reforms (Abd-El-Khalick et al., 2004).

Regarding this inclusive perspective; one may expect that both females and males are fairly portrayed in science textbooks that provide an important resource for teachers in schools. As various researchers indicate, textbooks are still being widely used in classrooms and continue to be an essential part of the curriculum. Science textbooks have played a dominant role in the teaching of science and have been mostly the science curriculum (Chiappetta & Fillman, 2007; Pizzini, Shepardson, & Abell, 1992; Kahveci, 2010). Furthermore, science textbooks are used as the primary organizer of subject matter at all levels of schooling (Chiappetta & Fillman, 2007).

Textbooks used in the teaching of many disciplines have been analysed to determine whether they provide fair and accurate coverage of particular topics or social groups. Evaluations of science textbooks involve various analyses from certain themes like gender equity (Elgar, 2004), questioning level (Pizzini et al.,1992), science vocabulary load (Groves, 1995), content accuracy (Hubisz, 2003), the inclusion of the nature of science aspects in biology (Chiappetta & Fillman, 2007; Irez, 2009) and chemistry (Abd-El-Khalick, Waters, & Le, 2008; Niaz, 2005) textbooks and misconceptions (King, 2010).

According to Elgar (2004), the amount of research effort devoted to the analysis of textbooks is in itself some indication of the importance many researchers attach to the messages that textbooks convey. Her study focuses on analysing a series of three lower secondary science textbooks used in Bruneian schools in terms of how equally females and males were represented in both illustrations and text. The results revealed that there is "clear gender imbalance in text and illustrations are in favour of males" (p. 891). In another study serving for a similar purpose, Walford (1980) examined the illustrations in 13 introductory science textbooks published in the 1970s, and found twice as many images of men as of women. He claims that gender bias in science textbooks may play a role in encouraging the view that "science is a boys' subject more than a girls' subject", and emphasizes the need to change 'the clear masculine face that science presents' (p.52). On the other hand, Potter and Rosser (1992) studied American life science textbooks for factors that might deter girls' interest in science. The researchers found a significant bias in favour of males in textbook illustrations similar to aforementioned studies. This, the authors believe, may convey the message that 'males are the norm in science' (p.669).

When the point comes to Turkish context, there are various studies focusing on gender issues in textbooks. As an outstanding example, Helvacioglu (1996) examined elementary level science textbooks published in Turkey between the years 1928 and 1995. Analysis of data led her to conclude that women were primarily depicted in traditional roles. In another study conducted by Özdoğru, Aksoy, Erdoğan, and Gök (2004), similar results were obtained. The researchers indicated that women were mostly assigned to roles like loving, caring, child-raising, at best as working in less prestigious jobs than males, if not housewives.

Keeping all these in mind, this study aims to investigate how males and females are represented in the textbooks adopting context-based approaches. The materials used in context-based courses vary from photocopiable worksheets to CD-ROMs but student textbooks comprise the backbone of each unit. Contexts and applications of science are used as a starting point for the development of scientific understanding throughout the textbooks. The shared aims of the courses in which these textbooks are used as the main resources are stimulating students' interest and enthusiasm for science and helping students acquire a better understanding of their natural environment without discriminating future science specialists and those who will not choose to continue with their study of science (Bennett & Holman, 2005). The most important reason of including textbooks used in context-based courses is that these courses hold the notion of "science for all". One may expect to see all aspects of equity throughout the textbooks. Considering all of these, this study aims to determine the gender balance of science textbooks used in A-levels (ages 16-18) in the UK.

METHODOLOGY

The six textbooks included in the study are selected due to adopting context-based approaches. The list of the books is presented at the end of the References.

In order to determine how equally females and males are represented in these textbooks, an unobtrusive research method, content analysis was applied. Based on counting and coding, illustrations and texts were analysed in detail. With regard to the illustrations, and following the methodology mentioned in the studies of Potter and Rosser (1992) and Elgar (2004), photographs and drawings were counted separately, as the impact on the reader of these two forms of illustration may be different. As in Walford (1980) and Elgar (2004), each photograph or drawing was classified according to whether it depicted only males or only females or both males and females. Fortunately, all the drawings were apparent enough to make a decision on the sex of the people portrayed. In just one instance, a drawing could not be categorized due to the lack of any gender reference on it. Photographs posed somewhat greater problems of analysis. In some photographs, it was impossible to determine the sex of people portrayed due to their positioning as very small, indistinct figures or wearing protective sports clothes and equipment like helmets that could belong to both males and females. Such photographs were not included in the analysis. There were also few photographs containing both distinct foreground figures and small, indistinct background figures which were categorized according to the sex of the foreground figures.

With regard to the analysis of the text, one of the aspects that seemed of interest from the point of view of gender representation was the number of people mentioned by name, and whether these were male or female. In this category different individuals were counted, rather than the total number of instances of names appearing in the text. Elgar (2004) suggested that counting each instance of a name would present a distorted picture, as the few individuals named mostly appear as protagonists in biographical narratives in which their names are mentioned repeatedly. In order to ensure this statement, each instance of a name was counted for two randomly selected textbooks which correspond to one third of the total number of the books analysed. It was seen that the discrepancy between the number of names that belong to males and females became greater due to having counted a male scientist's name 21 times and one other's 16 times. Furthermore, the names of scientists were only counted when they were mentioned as individuals. For instance, "Ziegler-Natta catalysis" was not counted until the text mentioned "Ziegler, the German scientist.." or "Haber process" is not counted until Fritz Haber was mentioned as a chemist.

RESULTS

Firstly, the frequency of males and females appearing in the illustrations in the textbooks were determined. From Table 1, it can be seen that photographs depicting males are more than three times as numerous as photographs depicting females. Moreover, the table shows that there are almost four drawings featuring males for every drawing featuring females. Thus, males are heavily over-represented in the illustrations.

The point where the textbooks differ is the way of the nouns used in the text. The analysis of the text revealed that it is common to mention individuals by their name. Totally, three of the four names (87%) mentioned in the text belong to males.

Textbooks	**Photos**			**Drawings**			**Nouns**	
	M	**F**	**B**	**M**	**F**	**B**	**M**	**F**
A	25	2	3	-	-	-	37	2
B	31	8	5	8	4	4	54	6
C	20	8	2	13	2	2	82	16
D	23	6	2	5	2	1	98	6
E	15	7	2	2	1	1	22	8
F	14	7	4	6	-	2	56	13
Total	**128**	**38**	**18**	**34**	**9**	**10**	**349**	**51**
%Total	**69.5**	**20**	**9.5**	**64**	**17**	**19**	**87**	**13**

Table 1. Frequency of different characteristics of representations of males and females

It is also considerable to mention that the only two photos depicting females in textbook A illustrates relatively passive roles like floating on the sea and representing suntanned skin. One of the two female names mentioned in the same textbook belongs to a fashion designer.

Although books B, E and F have more male images and names than females, an effort appears to have been made to avoid stereotyping with including photographs of females in scientific activities as chemist, astronaut, astronomer and researcher in a laboratory. Differing from other textbooks, B mentioned five of the female scientists with a Nobel Prize. The authors and publishers of book E have also apparently attempted to bear gender balance in mind when selecting names and illustrations but overall the numbers are in favour of males.

CONCLUSIONS AND IMPLICATIONS

This study is limited in the way that how any given text or illustration is interpreted depends in part on each individual's response to them. The power of the textbook, or even of the entire school curriculum, in the process of gender differentiation in science interests should not be overrated (Elgar, 2004). The gender variable interacts with other social variables such as race, religion, culture, and socio-economic status. Researchers dealing with gender-related issues should go beyond the textbooks.

However, the message delivered through the more frequent depiction of males, even not intended, may be received by students as science is for all students in school but preserves males more.

As Powell and Garcia (1985) mention, small representation of females in science-related occupational roles will limit the opportunities for young people to perceive females in scientific careers. They point out that illustrations in textbooks may be important in providing students with role models, enabling students to develop perceptions of themselves in possible societal roles in science, giving children the opportunity to view themselves as active participants in science-related activities, and providing children with positive self-concepts of themselves in relation to science (p.530). Their viewpoint is worthy of commendation and both the publishers and authors of textbooks should attempt to ensure further movement towards a balanced representation of the genders as new books are produced or revisions are made of existing books. However, it is not easy to achieve especially when the history of science aspect is included in the textbooks, a gender imbalance is inevitable. Such information can be accompanied by a discussion of the culture of the time, both societal and scientific. On the other hand, instead of emphasizing traditional roles of women, including females in scientific activities as chemist, astronaut, astronomer and researcher in a laboratory may be helpful. Furthermore, while selecting names that appear in questions, the authors and publishers should bear gender balance in mind.

In conclusion, textbooks are one of the major influences on students and more effort should be made to adequately address gender equity throughout the textbooks.

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Books investigated in the study

A: Salters Advanced Chemistry, AS Chemical Storylines, Heinemann, London, 2008

B: Salters Advanced Chemistry, A2 Chemical Storylines, Heinemann, London, 2009

C: Salters Horners Advanced Physics Project, AS Student Book, Edexcel Pearson, London, 2008

D: Salters Horners Advanced Physics Project, A2 Student Book, Edexcel Pearson, London, 2009

E: Salters-Nuffield Advanced Biology, AS Student Book, Heinemann, London, 2005

F: Salters-Nuffield Advanced Biology, AS Student Book, Heinemann, London, 2006

PART 12: PRE-SERVICE SCIENCE TEACHER EDUCATION

<u>Co-editors:</u> Dimitris Psillos and Rosa Maria Sperandeo

Pre-service professional development of teachers, instructional methods in preservice teacher education, programs and policy, field experience, relation of theory with practice, and issues related to pre-service teacher education reform.

This part corresponds to strand 12. It contains 36 papers.

TABLE OF CONTENTS OF PART 12

PRE-SERVICE SCIENCE TEACHER EDUCATION

ASSESSING PRE-SERVICE SCIENCE TEACHERS' TOPIC SPECIFIC PEDAGOGICAL CONTENT KNOWLEDGE (PCK): PRE-SERVICE SCIENCE TEACHERS' PCK OF ELECTROCHEMISTRY

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Abstract: Electrochemistry has been cited as one of the most difficult chemistry concepts for high school and college students to comprehend. Previous research reports show that students at all levels of education hold misconceptions about electrochemistry. Science education literature reveals that science teachers' pedagogical content knowledge (PCK) plays a critical role in helping students to overcome these misconceptions. However, currently there is not an assessment instrument that can be used to measure and enhance pre-service science teachers' topic-specific PCK. The purpose of this study was to develop and test the validity of a PCK assessment tool for measuring pre-service science teachers' PCK of electrochemistry. After the instrument was conceptualized and developed, it was administered to 31 pre-service science teachers. The findings suggest that pre-service teachers have limited PCK in electrochemistry. The findings suggest that pre-service science teachers primarily focus on using hands-on learning strategies rather than strategies that will cognitively challenge their students to learn science. Moreover, the findings show that the designed PCK instrument has significant potential to provide valid and reliable information on the sophistication level of pre-service science teachers' topic specific PCK. In addition, the findings suggest that the aforementioned instrument can be used as a teaching tool to enhance pre-service science teachers' topic specific PCK.

Keywords: pedagogical content knowledge, electrochemistry, pre-service teachers, assessment, science education

INTRODUCTION

Teaching science for conceptual understanding is one of the pillars of science education reform (American Association for the Advancement of Science [AAAS], 1993). Teaching science for conceptual understanding requires teachers adopting a curriculum that accurately represents scientific ideas, one that is relevant to students' personal lives, and promotes students' learning of science through inquiry. This also mandates the presence of teachers who are knowledgeable of the subject matters that they teach and hold pedagogical understandings, knowledge and skills that will allow them to teach science for conceptual understanding (Gallagher, 2007). However, many science classrooms across the globe are filled with teachers who are not well prepared to teach science for conceptual understanding. While some of them cannot teach science for conceptual understanding because of their limited subject matter knowledge, others lack pedagogical sophistication needed to teach science for conceptual understanding. However, past research reveals that neither sophisticated knowledge of subject matter nor sophisticated knowledge of pedagogy alone can result in teachers teaching for conceptual understanding (Shulman, 1986). The argument holds that for science teachers to teach science for conceptual understanding, they need to hold sophisticated pedagogical content knowledge (PCK) (Park & Oliver, 2008).

PCK has been conceptualized in multiple ways. While some have defined PCK as the knowledge used to transform subject matter content into forms that are comprehensible to the students (Grossman, 1990; Shulman, 1986, 1987), others have provided more specific accounts of PCK and have defined PCK as the amalgam of science teachers' knowledge of context, curriculum, pedagogy and assessment that hold potential to result in conceptual understanding among the students when enacted in the classroom (Park, Jang, Chen, & Jung, 2011).

Shulman (1987) defined PCK as "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p.8). Carter (1990) understood PCK as what teachers recognize about their subject matter and how they convert that knowledge into curricular events within the classroom. Grossman (1990) defines four essential components of a teacher's PCK: a) teachers' beliefs and knowledge of teaching a particular topic, b) knowledge of curriculum and curriculum materials, c) knowledge of common misconceptions held by students related to a particular domain of knowledge, and d) knowledge of particular instructional strategies and representations related to a particular topic. Park and Oliver (2008) built on this definition and added a new component called, "knowledge of assessment of students learning". Although PCK has been defined in slightly different ways, the transformation of content knowledge by the teachers for the purpose of effective teaching and enhanced student learning lie at the center of PCK (Park & Oliver, 2008).

Baxter and Lederman (1999) state PCK is constituted not only by what a teacher knows but also by "what a teacher does", and the reasons for the types of actions that he/she takes in relation to teaching a specific topic (p. 158). Shulman (1987) further argues that PCK involves teachers "from being able to comprehend subject matter for themselves, to becoming able to expose subject matter in new ways, reorganize and partition it, clothe it in activities and emotions, in metaphors and exercises, and in examples and demonstrations, so that it can be understood by students" as well (p. 13). These definitions imply that PCK must be understood and explored at two levels: 1) espoused PCK and 2) enacted PCK.

Espoused PCK refers to the amalgam of science teachers' knowledge of subject matter and their understanding of pedagogical strategies necessary to make a specific science topic comprehensible to their students. Espoused PCK is like a concept map that guides science teachers to make instructional decisions, the use of particular reinforcement materials and instructional strategies, while providing assessment of student learning (Park & Oliver, 2008). Teachers must have knowledge of what students know about a topic and areas of likely difficulty to employ PCK effectively (Park & Oliver, 2008). This means that pre-service teachers have to understand the knowledge of students' conceptions of particular topics, their learning difficulties, motivation, and diversity in their abilities, learning styles, interests, developmental level and language proficiency (Park & Oliver, 2008). Having such knowledge does not necessarily mean that they will use that knowledge in their teaching of science. When such knowledge get enacted in the classroom we call it enacted PCK. Enacted PCK refers to the type of PCK that can be observed during teaching. Park and Oliver (2008) maintain that enactment of PCK is a metacognitive activity. This implies that while the espoused PCK can help science teachers to design a lesson that reflects the best practices, enacted PCK is responsive to the students' learning needs as they present themselves during teaching.

The purpose of this study was to develop and test a PCK assessment tool to measure pre-service science teachers' PCK of electrochemistry. The focus of this study is espoused PCK. The researchers chose to focus on espoused PCK because measuring pre-service science teachers' enacted PCK is very labor-intensive and many science teacher educators lack human and financial resources to assess pre-service science teachers' topic specific PCK. For instance, it is not practical for a science teacher educator to spend two weeks on observing each of the 30 pre-service science teachers enrolled in their classrooms. The researchers focused on pre-service science teachers because pre-service science teachers often have a hard time converting their content knowledge into PCK, due to their limited experiences with teaching science for a diverse group of students. Also, electrochemistry is one of the most difficult subjects to learn for both teachers and students (Johnstone, 1980). Many researchers have documented that students have considerable difficulty in terms of understanding of electrochemical concepts (Garnett & Treagust, 1992; Sanger & Greenbowe, 2000). Given the abundance of students' misconceptions related to the electrochemical concepts, developing an instrument that we can use to measure pre-service science teachers' PCK of electrochemistry proves to be important. Our aim was to make several key elements of reform-based science curriculum, instruction and assessment visible to the pre-service science teachers by engaging them in reflection through a PCK assessment tool STSPCK (Secondary Teachers' Scientific Pedagogical content Knowledge) designed by the authors.

METHODS

Context

This study took place at a respected teacher education program in Turkey. The university where this study took place hosts 25000 students in 26 different majors. There are nine departments in the college of education at this university. All education programs are based on the five-year Holmes model. All pre-service teachers are required to complete a B.Sc. degree before they start to take education courses. Then, students spend one and a half year taking education courses in order to complete the teacher education program. All students graduate with a master's degree in their field of study and a license to teach in the secondary schools.

Participants

The participants consist of 31 pre-service chemistry teachers; 15 males and 16 females. Of the 31 participants, 10 were pre-service chemistry teachers in their senior year and 21 in their junior year of college. All pre-service chemistry teachers had completed the required subject matter courses prior to admission to the masters program and are currently taking pedagogical courses.

Data source and data collection procedure

Data source includes pre-service science teachers' responses to the STSPCK (Secondary Teachers' Scientific Pedagogical content Knowledge) instrument. After we granted the permission from human subjects committee, the students were informed of the purpose of the study and their participation in the study was sought. All 31 students agreed to participate in the study. After the students agreed to participate in the study, we administered the STSPCK to the participants.

STSPCK was developed by the researchers to assess pre-service chemistry teachers' PCK of electrochemistry. It consists of three parts with 30 items. The first part measures pre-service chemistry teachers' knowledge of reform-based curriculum and includes seven items. The second part consists of nine items assessing pre-service chemistry teachers' knowledge of reform-based instructional strategies. The third part includes 14 items regarding reform-based assessment and evaluation strategies. The pre-service chemistry teachers were asked to provide explanations and examples for each item considering electrochemistry, specifically "the galvanic cells".

The participants completed the STSPCK in one and a half hour. One week after the participants completed the STSPCK we asked the participants to use the STSPCK instrument and discuss their answers to the STSPCK in groups of two to four. The participants discussed their answers to the STSPCK instrument for one hour. These conversations were audio taped for analysis.

Data analysis

Data analysis was conducted in two stages. First, two authors read students' responses to the STSPCK instrument to identify statements that reflected the attributes of a sophisticated PCK and those that lacked such sophistication. These elements include: a focus on student-centered approaches to teaching science, promoting students' acquisition of scientific epistemologies, and assessing students' learning in science. In our analysis, we were interested in the specificity and quality of examples and strategies provided by the participants. By quality we mean examples or strategies that held the highest potential for promoting students' conceptual understanding of electrochemistry.

The STSPCK has three categories: curriculum, instruction, and assessment. We first analyzed participants' responses in each category and graded the quality of their responses for each category based on a scale that ranged from 1-10 with 1 representing the lower level of PCK knowledge and 10 highest level of PCK. Then, we gave each participant a cumulative score for each category: curriculum, instruction, and assessment. Finally, we categorized participants into 1) those that have naïve PCK, 2) those that have a developing PCK, and 3) those that have sophisticated PCK.

RESULTS

The findings indicate that the majority of the participants held naïve pedagogical content knowledge (PCK) related to electrochemistry as expected. We present the results under three categories: curriculum, instruction, and assessment.

Knowledge of curriculum

The findings indicate that the majority of participants held underdeveloped understandings of what it would take to make science curriculum reform-based. We analyzed participants' responses from two perspectives: student-centeredness of the instructional strategies expressed and the specificity of the instructional strategies that they expressed. We analyzed the strategies proposed by the participants in terms of their alignment with the science learning goals promoted by science education reform documents such as the NSES and Benchmarks for Scientific Literacy (AAAS). More specifically, we looked at the emphasis on inquiry, relevance of curriculum to everyday life, and equity. The participants were placed into one of the following categories in terms of the sophistication level of their PCK: naïve, developing, or sophisticated pedagogies.

In terms of the student-centeredness of the proposed strategies, 12 participants were placed in the naïve category, 12 were into the developing category, and six were into the sophisticated category. In terms of the specificity of the strategies that the participants expressed, 16 participants were put into the naïve category, 10 were into the developing category, and four were into the sophisticated category.

While the majority of participants emphasized the importance of inquiry-based learning, making science relevant to students' personal lives, making connections between the content of their teaching and students' cultural backgrounds, using problem-based curriculum, they failed to provide instructional examples that are specific to the teaching of galvanic cells. Similarly, findings indicate that the participants failed to discuss how the approaches that they adopted would help their students to achieve learning objectives. The results for this category are summarized in Figure 1.

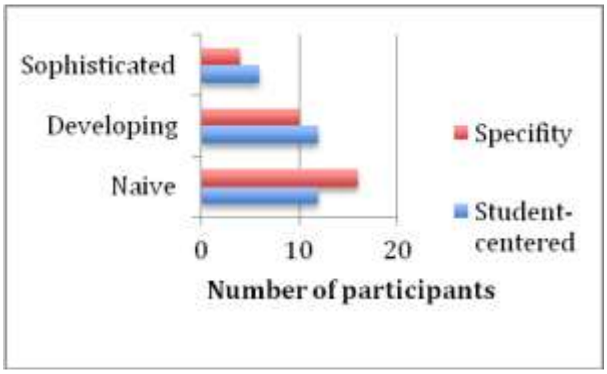

Figure 1. Participants' knowledge of curriculum

Knowledge of instruction

The results of our analysis show that the majority of the participants expressed underdeveloped understanding or knowledge of reform-based instructional strategies in the knowledge of instruction category. When the participants' responses were evaluated based on the criteria of student centeredness, 11 were placed under the naïve category, 11were under the developing category, and eight were under the sophisticated category. However, when the participants' responses were evaluated based on the specificity of the instructional strategies and examples, the number of participants under the naïve category went up from 11 to 16, of those in the developing category dropped to 10, and of those in the sophisticated category dropped from eight to four. These statistics are summarized in Figure 2.

While the participants were able to provide general instructional strategies such as using constructivist teaching methods, making the teaching of electrochemistry relevant to students' lives, engaging students in group-based activities, they failed to provide specific instructional strategies and examples that held potential to facilitate students' learning of science in ways that are consistent with those espoused in science education reform documents and current science education literature.

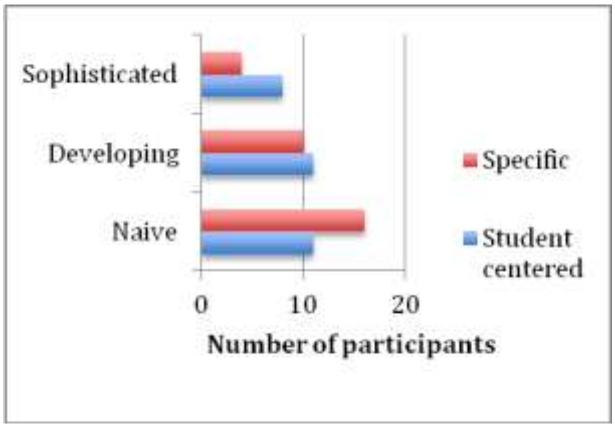

Figure 2. Knowledge of instruction

Knowledge of assessment strategies

The findings show that the participants had the most difficulty in the assessment category. When the participants' responses were evaluated based on the criteria of student centeredness, 15 were placed under the naïve category, six were under the developing category and nine were under the sophisticated category. However, when we used the criteria of the specificity, the number for participants who fell under the naïve category went from 15 to 19, of the developing category went from six to eight and of those that were placed in the sophisticated category dropped from nine to three. These statistics are summarized in Figure 3.

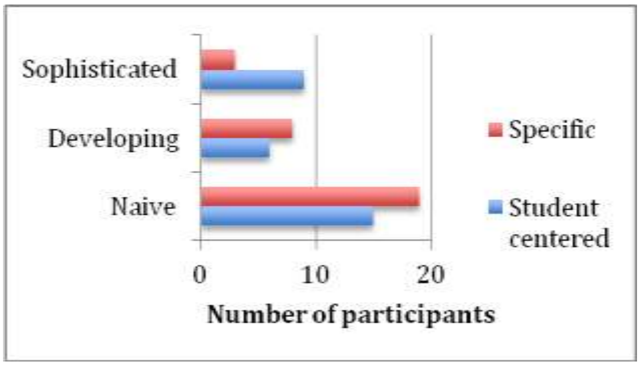

Figure 3. Knowledge of assessment

CONCLUSIONS AND IMPLICATIONS

There has been a growing interest in finding ways to enhance pre-service and in-service science teachers' PCK (Park & Oliver, 2008; Park et al., 2011). This emphasis on PCK is justified based on the assumption that a sophisticated PCK can make a significant impact on the quality of instruction that the students receive and thus the quality of learning the students experience in the classroom (Grossman, 1990; Park et al., 2011). For instance, Mansor, Halim and Osman (2011) looked at the impact of science teachers' PCK on students' conceptual understanding of cellular respiration and found that teacher PCK has a positive influence on students' conceptual understanding of cellular respiration. Traditionally, science educators have measured the sophistication level of teachers' PCK by having them to design a lesson plan or teach a mini lesson on a specific topic. These methods have limitations in that we cannot have pre-service science teachers to design a lesson for every topic and have no time to watch and evaluate students' mini lessons for every science topic in a semester-long, three-hour a week methods courses. Therefore, science educators continue to work on finding new ways to enhance pre-service science teachers' PCK of specific science topics. The results of this study show that the STSPCK can reliably measure pre-service science teachers' PCK. In addition, STSPCK can be used to help pre-service science teachers to identify their pedagogical needs so that science teacher educators could help pre-service science teachers to develop sophisticated PCK before they enter the classrooms of public and private K-12 schools. The current efforts of the researchers focus on using the STSPCK in physics concepts (i.e. momentum) and biology concepts (i.e. molecular genetics).

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MAPPING BELIEFS OF PRESERVICE PHYSICS TEACHERS IN THE CONTEXT OF A CURRICULUM INNOVATION

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Abstract: This work aims to investigate in the light of cognitive maps the beliefs of future teachers of Physics when working in a context of a curriculum innovation, particularly, the inclusion of Modern and Contemporary Physics topics into the High School curriculum. Our research methodology is of qualitative nature, of the case study type, and the data collection instrument consisted of a Likert questionnaire with 28 items carried out at the beginning and in the end of a mini-course on Particle Physics of 40h with a group of 11 preservice teachers on the Physics Teacher Training Course of the São Carlos Institute of Physics, at the University of São Paulo/Brazil, in 2009. As analytical framework for analyzing the collected data to build cognitive maps at the beginning and end of the mini-course. Among the findings to highlight to the epistemological beliefs: phenomenology, mathematical formalism, conceptual framework and ontology. For the didactic-pedagogical beliefs highlight: hierarchy of prerequisites, methodology of teachers, content selection, proposed activities and evaluation. Thus, among the principal implications of this work we would highlight: the need to provide teachers in their initial training with means to help them recognize their beliefs regarding Modern and Contemporary Physics, and instruments for evaluation and possible intervention with regard to their beliefs about the teaching and learning of Modern and Contemporary Physics topics in High School.

Keywords: Cognitive Maps, Curriculum Innovation, Beliefs, Qualitative Research, Modern and Contemporary Physics Teaching

BACKGROUND, FRAMEWORK AND PURPOSE

In recent decades, a curriculum innovation movement has been observed in several countries whose focus shifts from the content needs to the learner needs, what makes learners more motivated in learning situations potentially important and useful to them.

Some works highlight the involvement of teachers as a key-point for the success of a curricular innovation (Brown & McIntyre, 1978). They also call attention to the risks of non-adhesion and/or a failure to understand the proposed innovation on the part of the teachers (Fullan & Hargreaves, 1992). The possibilities of success increase significantly when the demand for change comes from within the teaching system itself, and is not seen by the teachers as an imposition of curriculum reformers.

On the other hand, despite these proposals for curriculum innovation developed in many countries, the traditional teaching has remained resistant to the new changes, and this is due largely to the knowledge and beliefs that teachers hold about the nature of their discipline, their personal and professional identity, as well as teaching and learning of specific contents (Davis, 2003; Feldman, 2002; Tobin & McRobbie, 1996; Pintó, 2002).

In this work our goal is to investigate in the light of cognitive maps the beliefs of future teachers of Physics when working in a context of a curriculum innovation, particularly, the inclusion of Modern and Contemporary Physics topics into the High School curriculum.

METHODOLOGY

Our research methodology was of qualitative nature, case study type, and the data collection instrument consisted of a Likert questionnaire with 28 items carried out at the beginning and in the end of the mini-course of 40h with a group of 11 preservice teachers on the Physics Teacher Training Course of the São Carlos Institute of Physics, at the University of São Paul o/Brazil, in 2009.

The preservice teachers participated in a mini-course on the subject of “Particle Physics”, totaling 16 hours, with the objective of providing conceptual tools to prepare them to work with the proposed topics. During the mini-course, teaching activities were developed and applied which dealt with topics such as: Rutherford scattering, particle detection, laws of conservation, fundamental interactions, the standard model of elementary particles and the connection between Cosmology and Particle Physics.

For this work, it was selected one preservice teacher’s data. The choice of this future teacher as an example to illustrate our analysis is justified due to the fact that his answers to the questionnaire are more representative of changes over the mini-course than the responses provided by other participants. This prospective teacher will be identified as Jonah. Below, it was made explicit his synthetic profile:

Teacher	Profile
Jonah	He always wanted to be a teacher and he considers the profession as very important, since the physics is in everything around us. The fact that he had always liked mathematics, mechanical and electrical objects helped him to choose to be a physics teacher. He would wish to pursue the profession after completing undergraduation.

After participating in the mini-course, in a second stage of approximately 20 hours, the preservice teachers had the task of analyzing the content studied in such a way as to adapt it and organize it into a teaching module, lasting 4 hours, which was delivered to High School students.

In recent years, cognitive maps have been used as analytical tool to interpret the Likert questionnaires in Science Education (Mellado et. al., 2002; Da-Silva, C., Mellado, V., Ruiz, C., & Porlán, R, 2007). In this research, they were used in order to structuring more comprehensive scenery of preservice teachers’ beliefs on different dimensions.

RESULTS

We built the initial and final cognitive maps highlighting the changes that occurred in the responses of preservice teachers from the beginning to the end of the mini-course. For such a differentiation, geometric figures and color changes were used between the five possible responses: strongly agree (dark green circles), agree (green circles), strongly disagree (dark red squares), disagree (red squares) or indifferent (yellow hexagon). About the colors and the questions that are listed in some geometric figures in the next two pages, it is important to clarify that all squares with red and dark red should be read negatively, because they report the disagreement with the item. The circles with green and dark green should be read in a positive way because they report the agreement with the item.

Therefore, we seek to determine the changes in Jonah’s conceptions both about the nature of knowledge of Modern and Contemporary Physics and his teaching and learning from the beginning to the end of mini-course.

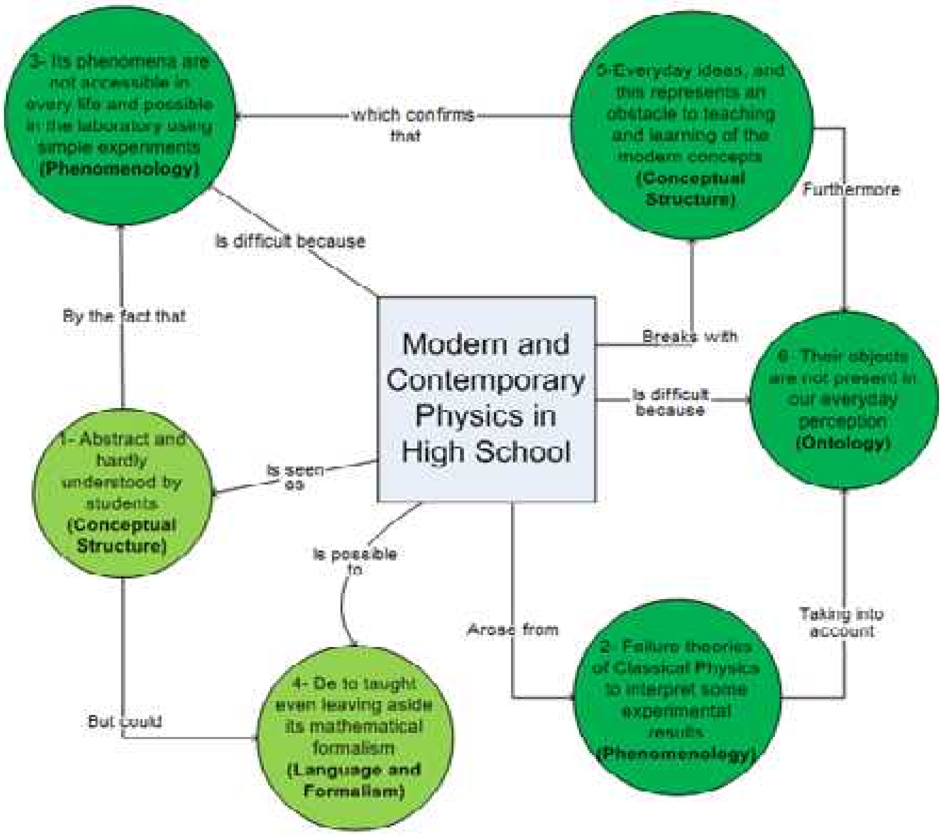

Fig. 01: Initial Epistemological Beliefs

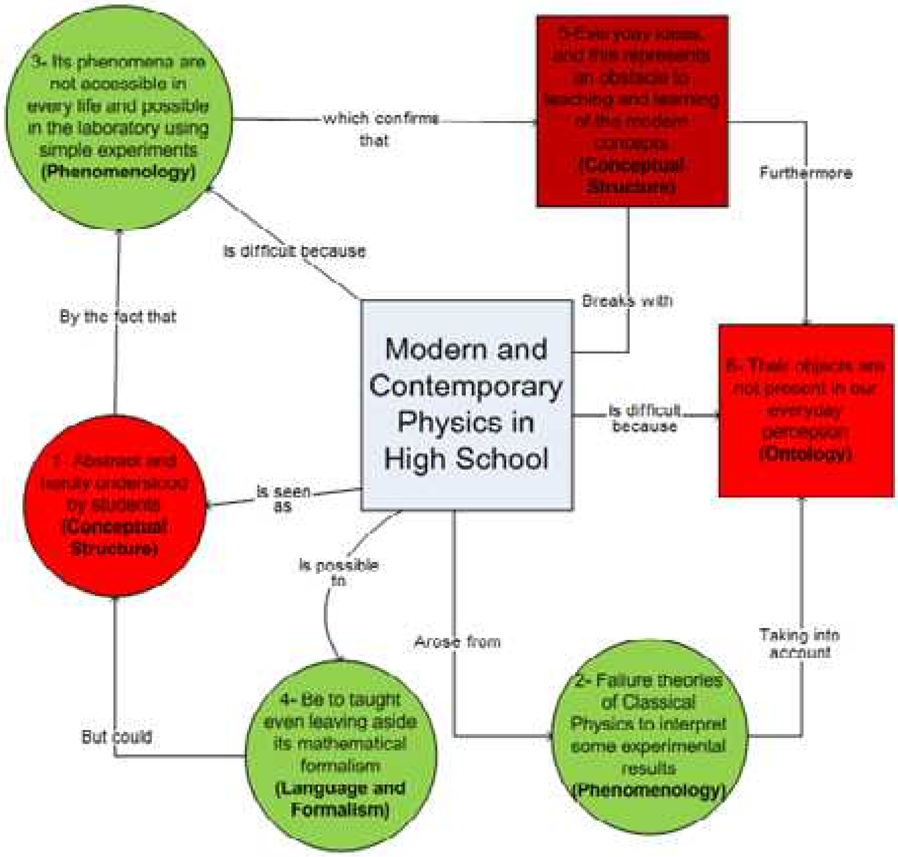

Fig. 02: Final Epistemological Belief

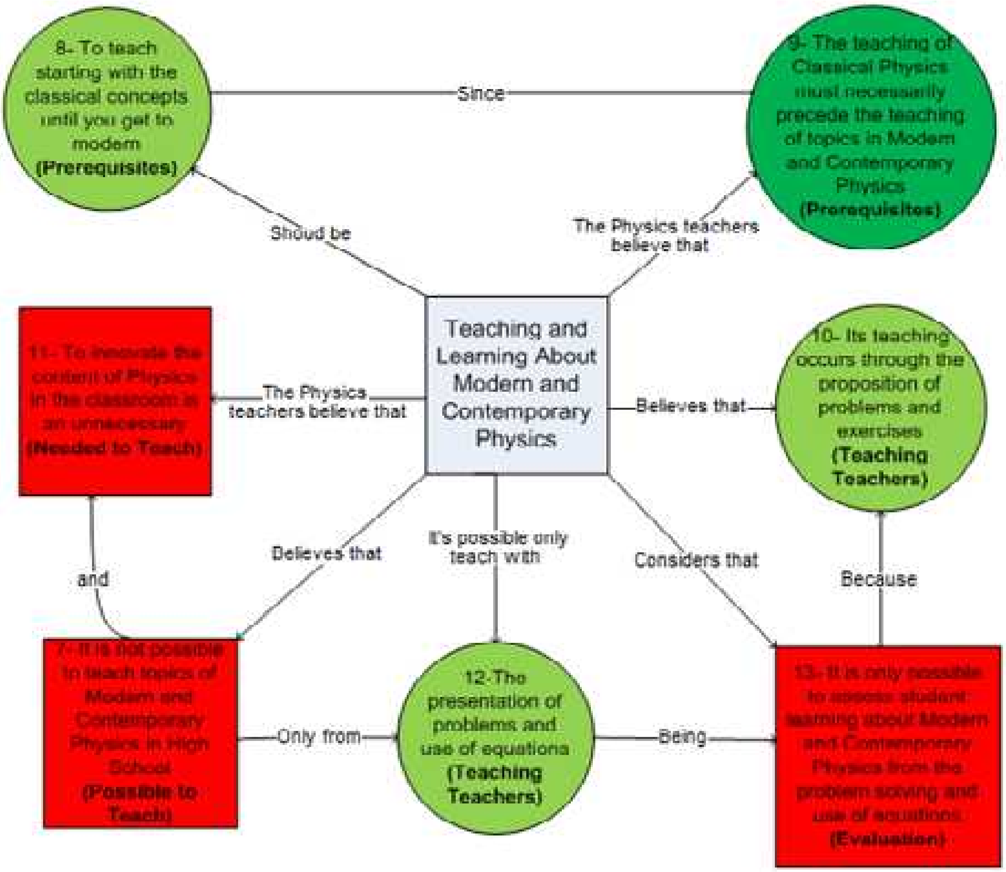

Fig. 03: Initial Didactic-Pedagogical Beliefs

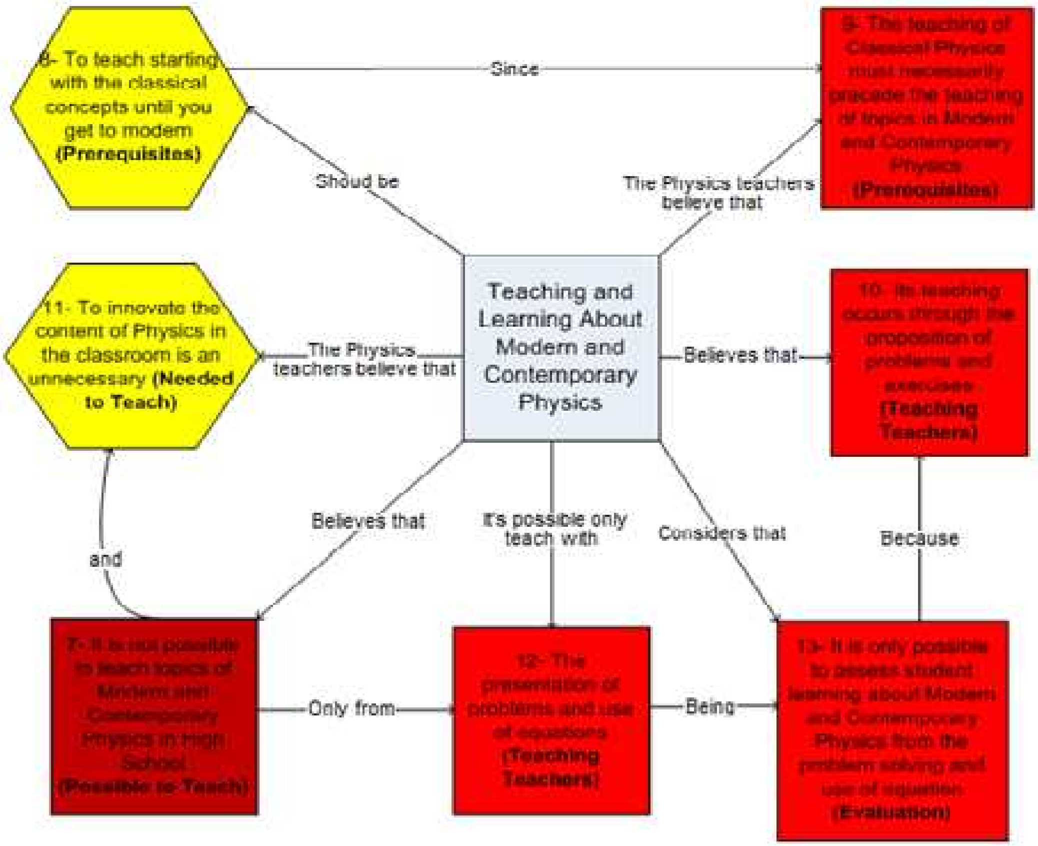

Fig. 04: Final Didactic-Pedagogical Beliefs

With respect to Jonah's epistemological beliefs (Fig. 01 and 02), we note that the question 4 was the only case in which changes were not observed, all others had some kind of change on a larger or smaller scale. Regarding to question 1, he has changed from agree to disagree, at some point Jonah noted that the Modern and Contemporary Physics was not always seen as abstract and difficult to understand; in questions 2 and 3 the changes were not as perceptible, in the beginning he was fully in agreement and in the end he only agreed; in question 5 there has been a big change, because in the beginning he agreed and in the end he fully disagreed that modern concepts break with everyday ideas, so it was not an obstacle to teaching and learning process; in question 6 there was also a significant change, in the beginning of the mini-course he fully agreed with the question and in the end he disagreed.

With respect to Jonah's didactic-pedagogical beliefs (Fig. 03 and 04), we note that in question 7 he disagreed in the beginning and in the end he disagreed completely; with respect questions 8 and 11, both were answered as indifferent in the end of the mini-course, the difference is that in question 8 he initially agreed and in the question 11 he disagreed; in the response to question 9 there has been a clearer change, because at the beginning of the mini-course he agreed fully with the question and in the end he disagreed; questions 10 and 12 had the same kind of change, at the beginning Jonah agreed and in the end disagreed.

In the light of the results obtained from Jonah's beliefs and from what the literature highlights, we would emphasize that it is necessary to know even more about the beliefs of future teachers regarding topics of Modern and Contemporary Physics and the their teaching at the High School level and that this will be an important first step in the attempt to set into action strategies to pursue changes and evolutions in the educational beliefs of preservice teachers with regard to the proposals of curricular innovation.

CONCLUSIONS AND IMPLICATIONS

We stress the importance of considering, for professional development, subjective variables present in preservice teachers, such as behaviors, attitudes, beliefs and individual life histories. In our investigation the future teachers were caught up in a bureaucratic discourse, which was more focused on completing an academic ritual, for example, concluding the activities on time, than being actively involved in the teaching activities proposed. Another belief identified in the statements of preservice teachers is the fact that they never acquired in their own school days any experiential knowledge related to topics of Modern and Contemporary Physics, compared with themes related to teaching Classical Physics.

The training courses for teachers will have to be even more geared to taking into consideration this research data in order to better prepare the teachers in this sense. Thus, among the principal implications of this work we would highlight, among other aspects: the need to provide teachers in their initial training with means to help them recognize their beliefs regarding Modern and Contemporary Physics, and instruments for evaluation and possible intervention with regard to their beliefs about the teaching and learning of topics of Modern and Contemporary Physics in High School curriculum.

An interesting perspective for research and teaching strategy for preservice physics teachers would discuss with them about their own beliefs concerning to the implementation of Modern and Contemporary Physics in high school. For this, cognitive maps can provide a good view of the restructuring of future teacher’s responses. Furthermore, when teachers educators seek to evaluating and discussing the future physics teachers’ beliefs on the insertion of Modern and Contemporary Physics in high school, they will benefit their students and start to develop strategies to cope with these beliefs along their initial or in service training courses.

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ANALYSIS OF A TEACHING EXPERIENCE IN THE CONTEXT OF A CURRICULUM INNOVATION

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Abstract: Currently there is a movement to reform the curriculum in many countries and the teachers beliefs in respect of how they teach what they know, about the contents itself and how these factors can change over time are aspects that need to be better understood during a curricular innovation in the classroom (Davis, 2003). In this work our goal is to advance the identification and analysis of the beliefs of preservice Physics teachers on the inclusion of Modern and Contemporary Physics topics in High School curriculum. We used the findings summarized by Pajares (1992) about educational beliefs in order to understand and establish some basic guiding principles to this research. Our methodology was qualitative nature in which was used semi-structured interviews as a tool for data collection. We applied a Content Analysis (Bardin, 1986) as an analytical framework. The interviews were conducted with a group of 11 preservice teachers on the Physics Teacher Training Course of the São Carlos Institute of Physics, at the University of São Paulo/Brazil, in 2009. It was possible to deduce from the beliefs studied the importance of working themes of Modern and Contemporary Physics in teachers training courses in terms of contents and educational to provide teachers with means of plan and make decisions with greater confidence to implement themes of Modern and Contemporary Physics in high school. Implications of the insertion of Modern and Contemporary Physics in curriculum are discussed.

Keywords: Physics Education, Teacher Training, Curriculum Innovation, Modern and Contemporary Physics, High School Curriculum.

BACKGROUND, FRAMEWORK AND PURPOSE

Currently there is a movement to reform the curriculum in many countries emphasizing the shift from a teaching paradigm that focuses on the transmission of content to one that emphasizes the needs of students so as to make them active individuals, through activities that are potentially meaningful to them and that are perceived as useful and relevant to their lives.

The teaching based on transmission of content, however, has resisted to new curriculum guidelines in function, in large part, of the teachers knowledge and beliefs about the nature of their disciplines, their personal and professional identities about teaching and learning of certain specific contents (Pinto et al., 2001).

In other words, the way in which teachers learn to teach what they know, how they form their knowledge, how they change over time etc… are factors that need to be better understood during a curricular innovation in the classroom (Davis, 2003).

Likewise, Tobin and McRobbie (1996) point to the existence of four cultural myths that surround the beliefs of teachers concerning the science curriculum: the myth of the transmission, the myth of efficiency, the myth of the rigor, and the myth of students' preparation for exams.

In this context lies this study, whose aim is to advance the identification and analysis of the beliefs of preservice physics teachers on the inclusion of Modern and Contemporary Physics in high school.

RATIONALE

Pajares (1992) summarized many findings on the study of beliefs in order to establish some basic guiding principles to guide further research in this direction: individuals' beliefs strongly affect their behavior, they are formed early and tend to perpetuate themselves even in face of contradictions caused by reason, time, experience or education and earlier a belief is incorporated, the harder it is to change it.

Moreover, changes in beliefs during adulthood are relatively rare phenomena in which occur general and deep changes - 'gestalt shifts' - in someone. Individuals tend to cling to beliefs based on incomplete or incorrect knowledge even after scientifically correct explanations are presented to them.

Finally, beliefs about teaching are already well established when a student arrives at university and those beliefs contribute to the definition of tasks and selection of cognitive tools with which to interpret, plan and make decisions regarding such tasks.

METHODOLOGY

The methodology of this research was of qualitative nature, case study type, in which was used semi-structured interviews as tools for data collection. We applied a Content Analysis (Bardin, 1986) as an analysis tool with the particularity that the same record unit could be related to more than one subcategory.

The interviews were conducted with a group of 11 preservice teachers on the Physics Teacher Training Course of the São Carlos Institute of Physics, at the University of São Paulo/Brazil, in 2009. The prospective teachers participated in a mini-course related to topics of Modern and Contemporary Physics totaling 16 hours with the aim of providing conceptual tools to them and prepare them to work with the proposed topics.

For this work, it was selected one undergraduate’s results. This prospective teacher will be identified as Roberto. Next, it was made explicit his synthetic profile:

Teacher	Profile
Roberto	He chose the teacher program according the following factors: his empathy with the physics, the availability of the course at night, his need to work during the day, and the fact that he enjoys teaching. But he does not intend to practice immediately, since they already have a steady job as a civil servant now, but he would intend to be a teacher in the future.

Fig. 1: Profile of undergraduate investigated

After participating in the mini-course, at another stage of approximately 20 hours, the student teachers had the task of analyzing the content studied in order to adapt it and organize it into a teaching module of 4 hours for high school students.

RESULTS

We present some of Roberto’s record units, as well as their related subcategories which were built from an inductive process in Fig.2.

It was possible organize the subcategories into more embracing categories as well: epistemological and didactic-pedagogical. Thus, we present in Fig. 3 a general scheme that helped us to organize and analyse the record units, our initial raw data, in order to make possible in the sequence to infer the prospective teachers' beliefs.

"It's the Modern and Contemporary Physics you get there the last hundred years which is the part that we see applied in all places of high-tech industry, everywhere you see the physics of the last hundred years." ***Everyday Content; Applied Content***
"I think it has advantages you teach Classical Physics before the Modern because students end up working with more concrete things, than work with abstract contents of Modern and Contemporary Physics." ***Teaching with Prerequisites; Abstract Content***
"When a person does not understand Modern and Contemporary Physics, you have to have a strategy to achieve that goal, to circumvent the mathematical formalism and circumvent the difficulties of abstraction of the contents of Modern and Contemporary Physics (...)". ***Knowing how to use Teaching Strategies; Difficult to Teach; Teaching with Mathematical Formalism; Abstract Content***
"(...) I learned modern physics in a non-teaching for high school students. In principle, what you do is teach the way you learned. At this time you cannot because students will not have especially the mathematics tools to understand what I teach. " ***Knowing how to use Teaching Strategies; Difficult to Teach; Teaching with Mathematical Formalism***
"I think it is going to need training teachers. I had access to training, right? I was trained, but for teachers already in service is not easy you get our Curriculum which has Modern and Contemporary Physics and apply that. " ***Knowing how to use Teaching Strategies; Difficult to Teach; Possible to Teach***

Fig. 2: Some record units from the interview with Roberto

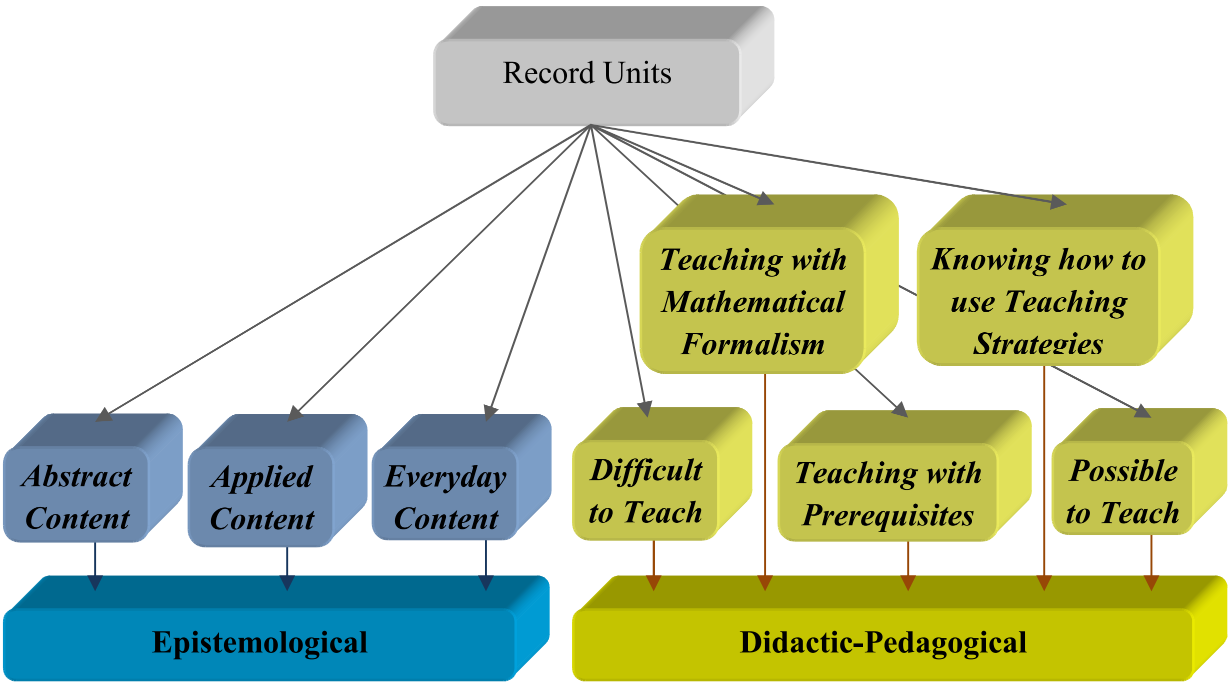

Fig. 3: General scheme of record units organization

From the interviews it was possible to infer the following epistemological and didactic-pedagogical beliefs of future teachers:

- The concepts of Modern and Contemporary Physics are abstract, while the classical concepts are more concrete;

- It is valid and possible to teach topics of Modern and Contemporary Physics in high school because they are content that may be applied in everyday life, but the feasibility of teaching is improved, especially when the teacher has a preparedness to deal with such topics in high school level;

- It is preferable but not necessary, that students know well classical concepts to work with Modern and Contemporary Physics concepts;

- Teach Modern and Contemporary Physics is something difficult due to no solid references of how to teach these topics to High School;

- The mathematical formalism withdrawal would be more difficult to teach Modern and Contemporary Physics in high school, because many contents of Modern and Contemporary Physics need mathematical rigor. But at the same time believes that students in high school would be unable to understand much of this formalism.

CONCLUSIONS AND IMPLICATIONS

Roberto's belief that classical physics is more concrete was created during his years of study along their initial formation. This belief was formed early and it tends to perpetuate itself even in face of contradictions and only through a great effort to explain how abstract classical physics concepts also can be is that such belief may be revised by future teachers and we can assume in this case that this phenomenon is general to the extent that this belief was built in common educational situations to many teachers.

Moreover, although this conclusion be obvious, it is possible to deduce from the beliefs of this teacher the importance of working themes of Modern and Contemporary Physics in teachers training courses in terms of contents and in terms of pedagogy to provide teachers with means of plan and make decisions with greater confidence to implement themes of Modern and Contemporary Physics in high school, especially when the teacher realizes that he himself has no references on how to teach these topics to high school.

Furthermore, as the beliefs about teaching are well formed when a preservice teacher arrives at university, only a good work in the initial teacher training courses can lay a solid foundation for consolidation of their beliefs about the inclusion of Modern and Contemporary Physics in high school, although this achievement is still a great challenge, since there is no consensus on how best to proceed in this sense.

We aim that stimulate in prospective teachers the belief that it is preferable but not required, that students know well the classical concepts for working with concepts of Modern and Contemporary Physics helps to create a more flexible environment for the insertion of Modern and Contemporary Physics in classroom.

We hope to contribute to the research focusing on teacher beliefs in a context of curriculum innovation, so that among the main implications of this work, we highlight the available compilation of the beliefs of teachers about the inclusion of topics in Modern and Contemporary Physics in High School.

This repertoire can be configured as a set of information for teacher trainers who wish to compare these results with those of their own students and seek to influence positively on their beliefs, improving the initial training of its undergraduates in what concerns the insertion of Modern and Contemporary Physics in High School.

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SELF-EFFICACY AND EMOTIONS IN PROSPECTIVE PRIMARY EDUCATION SCIENCE TEACHERS

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Abstract: A study is described of the self-efficacy of prospective primary teachers, and the relationship between this self-efficacy and the emotions they see themselves as having as future science teachers. The study was conducted through a questionnaire completed by 188 students in initial primary teacher education at the University of Extremadura during the academic year 2009-10. The results showed them to believe in their positive self-efficacy, and to have mostly positive emotions towards the Nature Sciences (biology and geology) but negative towards the Hard Sciences (physics and chemistry). Their self-efficacy had hardly any influence on their emotions in the Nature Sciences, but the students with positive self-efficacy had more positive emotions and fewer negative emotions in the Hard Sciences than those with negative self-efficacy.

Keywords: self-efficacy, emotions, science education, initial teacher education, primary teachers

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BACKGROUND AND FRAMEWORK

For many years, the study of emotions and feelings had been relegated to the fields of literature and art. Years ago, it would have seemed frivolous to introduce the study of these terms into education (Segura & Arcas, 2007), and even more so to relate them with specific school content or with other concepts such as self-efficacy. Fortunately today however, the idea that teaching is an emotional practice that involves both cognitive and affective processes is often fully accepted by researchers and educators (Garritz, 2009; Hargreaves, 2000; Shapiro, 2010; Van Veen et al., 2005).

In relation to science education, however, the affective has been far less investigated than the cognitive, and has usually been related more specifically to attitudes rather than to emotions. The First and Third Handbooks on Science Education provided two extensive reviews of attitudes (which included the emotions) in science learning. These were in the chapters of Simpson et al. (1994) and Koballa & Glynn (2007), respectively. In the Second Handbook, Bell (1998) dealt specifically with the science teacher's affective dimension.

Bandura (1977) defines self-efficacy as the belief in one's own ability to organize and execute the actions that one's profession requires. The notable influence of teachers' beliefs in their self-efficacy on their pupils' performance is a result of the teaching strategies they employ, which may favour or hinder learning (Prieto, 2007). Teacher self-efficacy research concludes that it is associated with much of teachers' behaviour, including instructional planning, their alternative ideas about the scientific content (Jones & Carter, 2007), the importance they attach to active learning (Enochs et al., 1995), their control and discipline in the classroom (Jones & Carter, 2007), etc.

Attempts to reach a consensus on a precise definition of emotion have always proved controversial and unsuccessful, meeting with widespread disagreement among authors, so that there is still no definition of emotion that is accepted by all. The working definition taken by our research group is that given by Bisquerra (2000), who defines emotions as reactions to the information we receive in our relationships in the environment.

The relationship between self-efficacy and emotions was already recognized in the analyses that some authors made of these two constructs. For Saarni (2000), emotional competence is the demonstration of self-efficacy in expressing emotions in social transactions.

Self-efficacy is not constructed from scratch, but is founded on judgements about one's own abilities. Emotional states are among the major sources of self-efficacy. Indeed, people differ in how they interpret their emotional states, and these emotional states also influence their judgements on their own competences. Positive emotions increase perceived efficacy, and negative emotions reduce it (Salanova et al., 2005).

Recent studies have addressed the empirical study of some emotional states as sources of self-efficacy in secondary school teachers. Llorens et al. (2005) showed in a sample of teachers that there are two ways of predicting self-efficacy from emotional states. One is that the perception of positive emotions is related to experiencing greater job engagement, which in turn acts as a source of the teacher's self-efficacy. The other is that low levels of self-efficacy are preceded by high levels of negative emotions. The findings of Salanova et al. (2005) were similar. Ritchie et al. (2011), in a study of a novice science teacher, find that positive emotions are related to the achievement of positive expectations and with the failure of negative expectations to actually be fulfilled, while negative emotions are related to the failure to achieve positive expectations. Other work has also shown that certain negative emotions can act as mediators between self-efficacy and its facilitators or obstacles (García et al., 2006), indicating that the fact of experiencing a negative emotional state affects the levels of self-efficacy.

PURPOSE

The study had two objectives: to compare the emotions in teaching the Nature Sciences (biology and geology) and the Hard Sciences (physics and chemistry), and to analyze the relationship between beliefs in self-efficacy and the emotions that initial teacher education students see themselves as having as future teachers of Nature Sciences or the Hard Sciences.

METHODS AND SAMPLES

An exploratory, descriptive study was conducted by means of a survey presented to 188 first-year students of Primary Education with no experience as teachers at the Education Faculty of the University of Extremadura, belonging to the First Degree Course in Primary Education during the academic year 2009-10. The instrument used was a questionnaire organized into two blocks. One was a Likert-scale set of items on self-efficacy, with four items presented in the form of statements or judgements on the respondent's self-efficacy as future teachers. These items were based on two published questionnaires on the self-efficacy of prospective teachers – STEBI-B (Enochs & Riggs, 1990) and that of Uzuntiryaki & Capa Aydin (2009).

The other block was a table of emotions in which the participants were asked to mark which of the 24 emotions offered they believed they would experience as future primary science teachers, for both the Nature Sciences (Biology and Geology) and the Hard Sciences (Physics and Chemistry). These emotions were chosen following the proposals of Bisquerra (2009) and Damasio (2010), distinguishing between positive and negative emotions.

The resulting data were subjected to the necessary processes of checking, coding, and digital storage in order to proceed with their descriptive analysis using SPSS (Statistical Product and Service Solutions) 18.0.

RESULTS

Although there is only one science subject in primary education, we distinguished topics in the curriculum related to the hard sciences (Physics or Chemistry) and those related to the nature sciences (Biology or Geology) in order to explore what emotions the respondents believed they would experience in each of these areas. The reliability analysis of the emotions questionnaire gave a value of 0.835 for Cronbach's alpha, corresponding to a good level of reliability.

The results showed the prospective primary school teachers to have conflicting emotions about their future teaching of content related to the Nature Sciences as compared with those related to the Hard Sciences (Figure 1). For the Nature Sciences the predominant feelings were all positive (motivation, interest, curiosity, tranquillity, enthusiasm, etc.), while for the Hard Sciences the predominant feelings were all negative, with the highest percentages being reached for fear, tension, worry, nervousness, and distress. This result is consistent with previous studies of other samples of prospective primary teachers in their initial teacher education (Brígido et al., 2010).

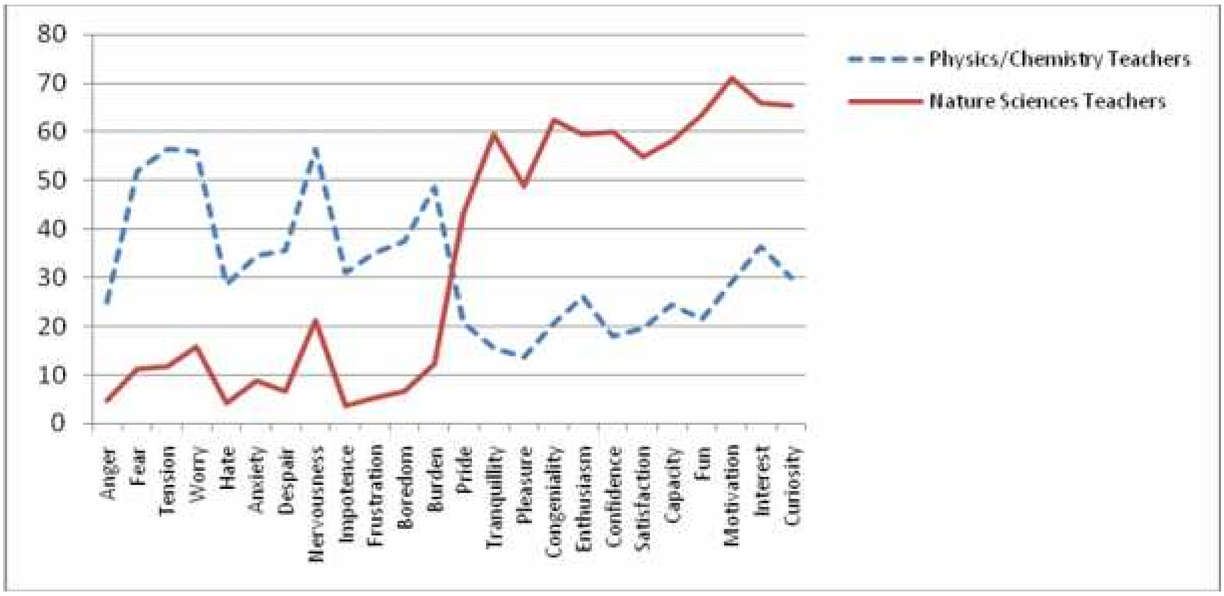

Figure 1. “Comparison of emotions in teaching Nature Sciences or the Hard Sciences”

The results indicated that the majority of respondents (67.4%) believed highly in their self-efficacy for their future science teaching. Relating this result with the emotions concerning Nature Sciences, we found few differences between respondents with high or low beliefs about their self-efficacy in the subject of Nature Sciences (Figure 2).

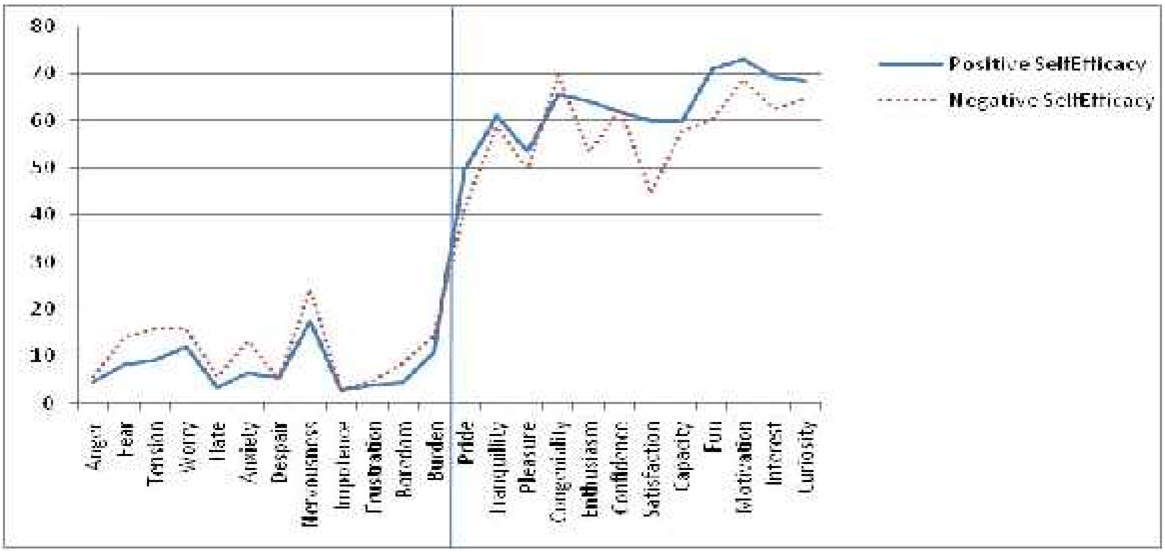

Figure 2. “Emotions in Nature Sciences according to beliefs concerning self-efficacy”

In the case of the Hard Sciences however (Figure 3), the prospective teachers with positive self-efficacy had more positive emotions and fewer negative emotions than those with negative self-efficacy.

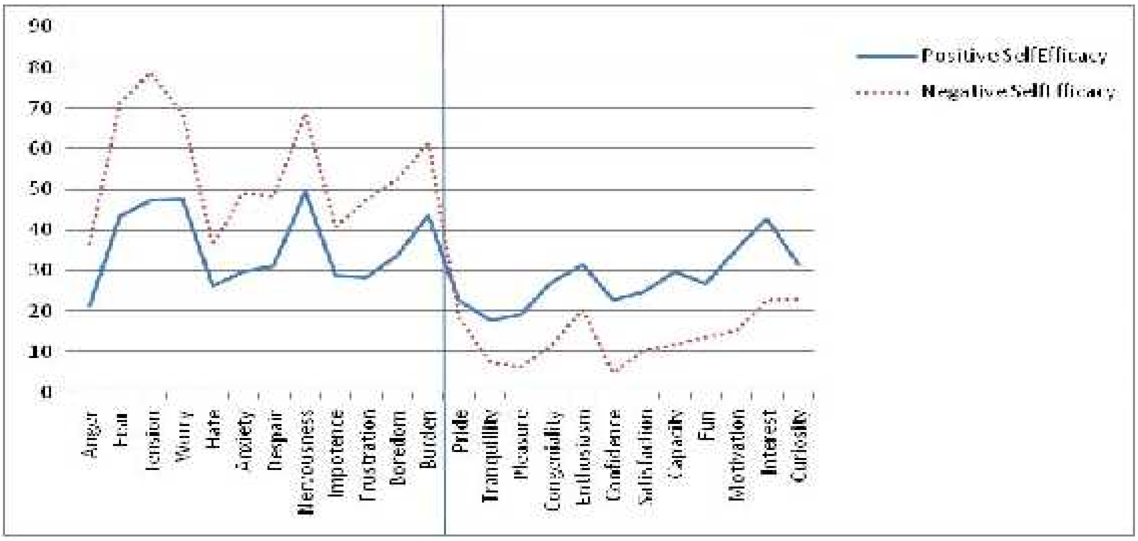

Figure 3. “Emotions in Hard Sciences according to beliefs concerning self-efficacy”

CONCLUSIONS AND IMPLICATIONS

The emotions of pre-service primary teachers in teaching depend on the scientific subject to be taught. In the Hard Sciences (physics and chemistry), the emotions are mostly negative, while in Nature Sciences (biology and geology) they are very positive.

Positive beliefs in self-efficacy in their future science teaching predominate over negative beliefs. There is little difference between the self-efficacy beliefs and the emotions in the future teaching of Nature Sciences. But teachers with positive self-efficacy beliefs also have more positive emotions and fewer negative emotions concerning the Hard Sciences than those who have negative self-efficacy.

With respect to the implications, we believe that the study of emotions is important in the context of initial teacher education. It can help them on the one hand to become aware of their own possible emotional vulnerability, of their time at school, and of how emotions affect teaching and learning the different science subjects, and on the other to develop the capacity to self-regulate those emotions. Younger teachers are more likely to incorporate educational changes into their practice, and to consider the emotional dimension of those changes (Hargreaves, 2005). It is therefore necessary to develop programs of intervention and emotional support for prospective teachers (Appleton, 2008, Koballa et al., 2008; Shoffner, 2009) in order for them to gain in emotional competence – an aspect on which we are currently working. The results of our study, together with other research, also suggest the need to include in teacher education programs strategies for the improvement of self-efficacy (Hoy & Spero, 2005), especially in subjects like Physics or Chemistry which show themselves to cause prospective primary teachers major cognitive and emotional difficulties.

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PRE-SERVICE SCIENCE AND PRIMARY SCHOOL TEACHERS' PERCEPTIONS OF SCIENCE LABORATORY ENVIRONMENT

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Abstract: The associations between students' perceptions of science laboratory environments, science achievement, and their attitudes towards science have been examined extensively in science education literature (Wong & Fraser, 1994; Hofstein, & Cohen, 1996; Lee & Fraser, 2001; Özkan, Çakıroğlu, & Tekkaya, 2008); however, there have been limited studies focusing on pre-service teachers' (PTs). The purpose of this study was to examine pre-service elementary science teachers' and primary school teachers' perceptions of science laboratory environment and to investigate its relationship with their achievement in science laboratory and attitudes towards science lessons. The differences in PTs' perceptions of laboratory environment by their major area were also investigated. Participants of this study were 178 PTs enrolled in science laboratory course in the departments of elementary science education and primary education. Data were collected through Science Laboratory Environment Inventory (Fraser, Giddings, & McRobbie, 1995) and Science Attitude Scale (SAS) (Geban, Ertepınar, Yılmaz, Altın, & Şahbaz, 1994). In order to investigate the relationship between participants' perceptions of science laboratory environments, their attitudes toward science lessons and their achievement in science laboratory, simple correlation analysis was used. MANOVA was also used to investigate the differences across departments. The findings indicated that most of the participants have high scores on SLEI subscales except Open-Endedness subscale (M=19.33, SD=3.62). Simple correlation analysis results showed that both achievement and attitude are positively related to Integration subscale of SLEI. Moreover, department has found to be a significant factor differentiating PTs' perceptions of laboratory environment in Student Cohesiveness and Material Environment subscales. Although this difference is statistically significant, there are not any major differences between mean scores of two groups. On the other hand, SAS mean scores of pre-service primary school and elementary science teachers were found to be significantly different. PTs majoring in science education have high positive attitudes toward science compared to pre-service primary school teachers.

Keywords: Science Laboratory, Pre-service Teachers, Science Education, Learning Environment, Attitude.

BACKGROUND, FRAMEWORK, AND PURPOSE

Science laboratory has a crucial role in science education as it gives students a chance to embody their theoretical knowledge. In the literature, there have been many studies investigating the relationship between students' perceptions of laboratory environments and students outcomes (e.g. Özkan, Çakıroğlu, & Tekkaya, 2008). Previous studies have consistently showed that there is a strong relationship between students' laboratory environment perceptions and their outcomes. The possible effects of other student characteristics such as gender, grade level, subject, school type were also investigated with different studies all around the world (e.g. Wong & Fraser, 1994).

The purpose of this study was to examine pre-service elementary science teachers' and primary school teachers' perceptions of science laboratory environment and to investigate its relationship with their achievement in science laboratory and attitudes towards science lessons. In this study, the differences in pre-service teachers' (PTs) perceptions of laboratory environment by their major area were also investigated. The following research questions guided the study:

1. Is there a relationship between PTs' perceptions of their science laboratory learning environment and their science laboratory achievement?
2. Is there a relationship between PTs' perceptions of their science laboratory learning environment and their attitudes toward science lessons?
3. Is there a significant difference in PTs' perceptions of their science laboratory learning environment and their attitudes toward science lessons by their departments?

RATIONALE

The associations between students' perceptions of science laboratory environments, science achievement, and their attitudes towards science have been examined extensively in science education literature (Wong & Fraser, 1994; Hofstein, & Cohen, 1996; Lee & Fraser, 2001; Özkan, Çakıroğlu, & Tekkaya, 2008). However, there have been limited studies focusing on pre-service teachers' perceptions of science laboratory environments. PTs' perceptions of the learning environment can give valuable information to improve the effectiveness of science laboratory in the teacher education programs. The effectiveness in science laboratory is very important for pre-service teachers because they will teach science and conduct laboratory applications in their future schools.

METHODS

Sample

The participants of this study were 178 pre-service teachers enrolled in science laboratory course in the departments of elementary science education and primary education at Sakarya University in Turkey. Of the 178 participants, 89 were 3th year students majoring in elementary science education (69 female, 20 male students) and 89 were 2th year students majoring in primary education (72 female, 17 male students). Although the students from different departments attend different science laboratory courses, the course content and objectives are very similar and also both of these two courses are offered by the department of elementary science education. They use the same laboratory for the courses and conduct very similar experiments. The aim of the both courses is to help PTs to gain the ability of designing and applying experiments for science lessons.

Instrumentation

The data were collected through Science Laboratory Environment Inventory (SLEI) and Science Attitude Scale (SAS). Both of the questionnaires were administered at the same time to the participants. The first instrument, the SLEI, used to investigate PTs' perceptions of science laboratory environment, was developed and validated by Fraser, Giddings, and McRobbie (1995) and adapted into Turkish by Özkan, Çakıroğlu, and Tekkaya (2008). This questionnaire consists of 35 items and 5 different subscales with 7 items in each subscale (Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment). In the current study, the alpha reliability coefficients of the subscales were found to be range from .60 to .78 with a total scale reliability of .79.

The second instrument SAS was used to assess students' attitude toward science lessons, and developed by Geban, Ertepınar, Yılmaz, Altın, and Şahbaz (1994). In the current study, the Cronbach alpha coefficient of this 15 item 5-point Likert type scale was found to be .94.

Data Analysis

In order to investigate the relationship between participants' perceptions of science laboratory environments, their attitudes toward science lessons and their achievement in science laboratory, simple correlation analysis was used. For this analysis, PTs' course grades are used as science laboratory achievement variable. Moreover, Multivariate Analysis of Variance (MANOVA) was also used to investigate the differences across departments on five different subscales of SLEI and SAS.

RESULTS

Descriptive Statistics

Pre-service teachers' perceptions of their laboratory environment were described by their responses to the SLEI in its five subscales; Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. The results showed that PTs see their science laboratory environment positively, as indicated by mean scores for subscales ranging from 2.78 to 4.04 over 5 (Table 1). The highest mean score of all subscales was for the Student Cohesiveness subscale (M=4,04, SD=.48) suggesting that students perceived great cohesiveness in their laboratory and they were helpful and supportive of each other. The second highest mean score was for the Integration subscale (M=3.96, SD=.40), indicating that students thought their laboratory activities were related to their theoretical courses. The mean score for the Rule Clarity subscale (M=3.94, SD=.54) was also high, implying that rules for laboratory courses and experiments were clear enough and students knew what they were supposed to do or not to do in the laboratory. For the Material Environment subscale the mean value can be considered as moderate (M=3.71, SD=.54). This means materials in the laboratory were found as an adequate by the students. The lowest mean score of all subscales was for the Open-Endedness subscale (M=2.78, SD=.42) indicating that students perceived a close-ended approach for their laboratory activities.

Table 1: Mean Scores of Pre-service Teachers' on Five Subscales of SLEI

	Mean	SD
Student Cohesiveness	4.04	.48
Open-Endedness	2.78	.42
Rule Clarity	3.94	.54
Integration	3.96	.40
Material Environment	3.71	.54

Simple Correlations Results

Simple correlation analysis results (Table 2) revealed that among five subscales of SLEI only Integration subscale was significantly and positively related to science laboratory achievement and to attitude toward science lessons with small effect size. Correlation coefficients of .10, .30, and .50, are interpreted as small, medium, and large effect size respectively (Green, Salkind, & Akey, 2000).

Table 2: Simple correlations with SAS scores and science laboratory achievement

		Student Cohesiveness	Open Endedness	Integration	Rule Clarity	Material Environment
Science laboratory achievement	Pearson Correlation	-.076	-.010	.152(*)	-.004	-.009
	Effect Size	.07	.01	.15	.00	.00
Attitude toward science lessons	Pearson Correlation	-.077	-,062	.268(**)	.020	-.012
	Effect Size	.07	.06	.26	.02	.01

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Multivariate Analysis of Variance Results

A one-way between-groups multivariate analysis of variance was performed to investigate the differences across departments on five different subscales of SLEI and SAS. Preliminary assumption testing was conducted to check for normality, linearity, singularity and homogeneity of variance-covariance matrices, with no serious violations noted. MANOVA results comparing pre-service primary school teachers and elementary science teachers revealed that there was a significant difference between them on the combined dependent variables: $F(6,171)=29.63$, $p=.000$; Wilks' Lambda=.49; partial eta squared=.51. When the results for the dependent variables were considered separately, the differences to reach statistical significance using a Bonferroni adjusted alpha level of .008 were on the Student Cohesiveness subscale, $F(1,176)=12.63$, $p=.000$, partial eta squared=0.067; on the Material Environment subscale, $F(1,176)=13.16$, $p=.000$, partial eta squared=0.070; and on the attitudes toward science lessons, $F(1,176)=125.93$, $p=.000$, partial eta squared=0.417. An inspection of the mean scores indicated that on Student Cohesiveness (SC) and Material Environment subscales (ME) pre-service primary school teachers have higher mean scores with small effect size, whereas pre-service elementary science teachers have higher science attitude mean scores with large effect size. Mean scores and % variance explained by department in Student Cohesiveness and Material Environment subscales and Science Attitude Scale are presented in Table 3.

Table 3: Mean scores and percentage variance explained by department

		SC	ME	Attitude
Pre-service elementary science teachers	Mean	27.67	25.09	59.61
Pre-service primary school teachers	Mean	29.37	27.07	44.49
	% variance explained	6.7	7.0	41.7

CONCLUSIONS AND IMPLICATIONS

The findings of this study indicated that most of the participants have high scores on SLEI subscales except Open-Endedness subscale (M=19.33, SD=3.62). It can be concluded that although participants see their science laboratory environment positively, they think laboratory activities are close-ended. This finding is consistent with previous studies conducted with elementary and high school students (e.g. Lee & Fraser, 2001). This may be because experiments and their procedures are determined for students, they just follow the given guidelines and neither instructors nor students try to change this system in Turkey (Çakıroğlu, Telli, & Çakıroğlu, 2003). However, an open-ended approach might be more helpful to future teachers to find their own way to teach science and conduct laboratory experiments. Moreover, if pre-service teachers do not receive an open-ended instruction, they cannot be expected to be an innovative teacher in the future.

Simple correlation analysis results showed that both science laboratory achievement and attitude toward science lessons are positively related to Integration subscale of SLEI. Students who perceive greater integration between theoretical courses and laboratory applications have more positive attitudes toward science lessons and perform better in science laboratory courses. This finding is consistent with previous studies (e.g. Özkan, Çakıroğlu, & Tekkaya, 2008). Moreover, as the integration between theoretical courses and laboratory applications increases, students’ chance to embody their theoretical knowledge also increases and then they perform better and gain a more meaningful understanding.

In this study, department has found to be a significant factor differentiating students’ perceptions of laboratory environment in Student Cohesiveness and Material Environment subscales. Although this difference is statistically significant, there are not any major differences between mean scores of two groups. On the other hand, the significant difference between SAS mean scores of pre-service primary school and elementary science teachers is found. PTs majoring in science education have high positive attitudes toward science compared to pre-service primary school teachers.

Future research may be conducted to investigate the reasons of differences on attitude towards and achievement in science laboratory courses between primary education students and science education students and its influences in science education. Primary education PTs and science education PTs may be compared in terms of their pedagogical content knowledge level of science laboratory courses.

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CONCEPTIONS OF PROSPECTIVE TEACHERS ON NATURE FIELD TRIPS IN RELATION TO OWN EXPERIENCES AS PUPILS

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Abstract: Numerous studies have shown that the nature field trips are a very important activity for pupils in the teaching and learning of Biology and Geology. But little research has been done on the specific knowledge of teachers concerning these activities, and even less has focused on prospective teachers. The present study was thus an exploratory analysis of the importance prospective teachers attach to nature field trips, examining whether their experiences with these activities while they themselves were pupils had any bearing on their conceptions as future teachers. We designed a questionnaire that was completed by 35 prospective secondary education teachers. These pre-service teachers were very much in agreement with the importance of these activities in enhancing their pupils' motivation and performance, and that these trips have an essential role to play in the teaching and learning of these subjects. Nonetheless, they did not value these activities equally highly in their own experience as pupils at school, and for many of them such field trips had been of no great importance in their learning these subjects. No relationship was found between their poor experiences in this sense as pupils and their views as teachers. The study thus points to an important issue in that the prospective teachers' expectations with respect to nature field trips may not be translated into any positive effect on their pupils' learning.

Keywords: Science field trip; Teacher development; Teaching and learning activities; Pædagogical Content Knowledge; affective domain.

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BACKGROUND, FRAMEWORK, AND PURPOSE

Numerous studies have shown that nature field trips have a positive effect on pupils in both cognitive and attitudinal aspects (Falk, 1983; Bitgood, 1989; Rudman, 1994; Meredith et al., 1997). Most have focused on the pupils, and have described key aspects of these teaching-learning activities (Michie, 1998) together with their great complexity (Hurley, 2006). However, few have been directed at considering the specific knowledge that teachers use in these activities as a part of their overall pædagogical content knowledge (Shulman, 1986). This lack of information is even more patent with respect to initial teacher education. Indeed, one knows none of the aspects related to the cognitive and emotional domain of prospective teachers with respect to pupils' nature field trips, even though studies have found that such activities are fundamental to the education of teachers of biology, contributing to their construction of biological knowledge and pædagogical content knowledge, and fostering their reflection on their career as teachers (Amortegui et al., 2010). Besides the knowledge concerning nature field trips that teachers acquire at this stage of their education, prospective teachers have already accumulated information and attitudes about this activity as a result of their own experience as pupils as part of their continuous evolution from school age to their eventual professional development (Porlán et al., 2010).

RATIONALE

The aim was to make an exploratory analysis of the importance that prospective Biology and Geology teachers attach to nature field trips in the teaching and learning process of these subjects, and to inquire into their own experiences at school in these activities, and whether these experiences had any influence on their conceptions as future teachers.

METHODS

A specific questionnaire was designed (see Table 1) which was completed on a voluntary and anonymous basis during the 2009-10 academic year by 35 prospective teachers doing the Master's degree course in Secondary Teacher Education at the University of Extremadura in the speciality of Biology and Geology. A Spearman correlation analysis was performed to determine whether their present conceptions about nature field trips had any relationship with their own experiences as pupils in these activities.

Respond to the following statements with an X indicating which option you consider most closely expresses your degree of agreement. The scale is from 1 to 10, where 1 represents the greatest degree of disagreement.											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
As Teacher											
Item 1	The importance of nature field trips has to do with increased motivation.										
Item 2	The effort in time, money, and material is rewarded by improved teaching and learning due to nature field trips.										
Item 3	The function of these nature field trips in learning concepts is not essential.										
As Pupil											
Item 4	They increased my motivation towards topics related to Biology and/or Geology.										
Item 5	They served mainly as a recreational activity rather than as something educational.										
Item 6	They meant a major improvement in my process of learning science.										

Table 1: Questionnaire used in the study.

RESULTS

The prospective teachers believed that nature field trips are very important in teaching and learning Biology and Geology (Figure 1). The vast majority of them see these activities as playing a key role in motivating pupils in these subjects: the median of their responses to Item

1 ("*The importance of nature field trips has to do with increased motivation*") was 9 (mean 8.97 ± 1.25, n = 35).They were also very much in agreement with the effect of these trips in improving their pupils' learning process: the median of their responses to Item 2 ("*The effort in time, money, and material is rewarded by improved teaching and learning due to nature field trips*") was 8 (mean 8.15 ± 1.40, n = 34).

Finally, they saw these activities as playing an essential part in pupils' learning: the median of their responses to Item 3 ("*The function of these nature field trips in learning concepts is not essential*") was 3 (mean 3.23 ± 2.20, n = 35). Nonetheless, their responses to Items 2 and 3, especially to the latter, reflected a certain disagreement among the prospective teachers (Figure 1).

Figure 1: Responses as future teachers to the questionnaire on nature field trips.

Their views as future teachers about nature field trips were different from their experiences as pupils (Figure 2). With respect to motivation towards Biology and Geology when they were pupils, most were in agreement that this had been enhanced by the field trips, although there was not the same uniformity of opinion as when they viewed these activities from a teaching standpoint (Figure 2). The median of their responses to Item 4 ("*They increased my motivation towards topics related to Biology and/or Geology*") was 8 (mean 7.03 ± 2.77, n = 34).

With respect to the importance of these activities, the prospective teachers did not see them as having had any great relevance in their experiences as pupils. For many of the respondents, these nature field trips played a recreational rather than an educational role: the median of their responses to Item 5 ("*They served mainly as a recreational activity rather than as something educational*") was 6 (mean 6.09 ± 2.08, n = 35). Although most of the respondents recalled these trips as helping to improve the learning process, this was not the case for a significant fraction of them. The median of their responses to Item 6 ("*They meant a major improvement in my process of learning science*") was 8 (mean 7.57 ± 2.06, n = 35). No statistically significant correlation was found between their responses corresponding to their views as future teachers and those corresponding to their experience as pupils.

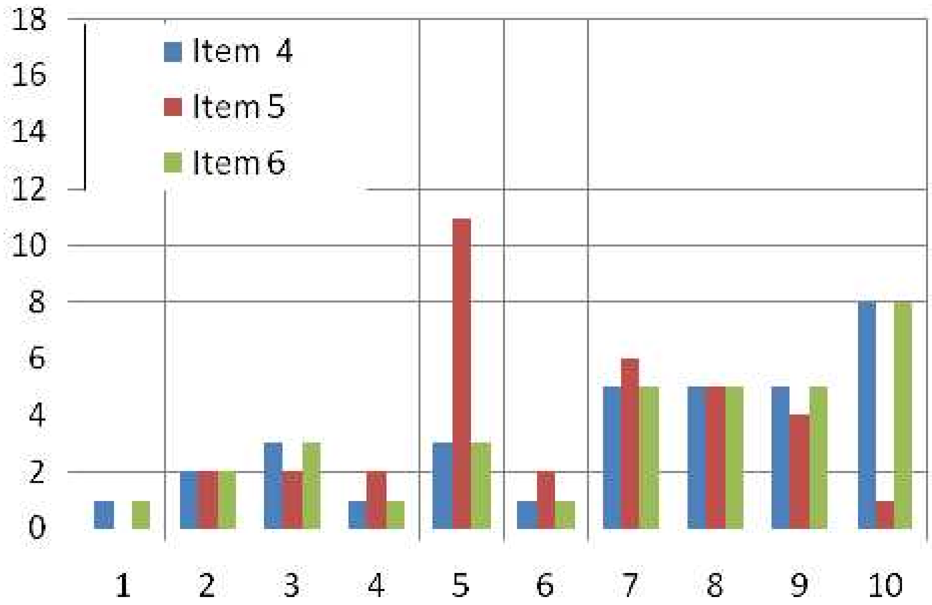

Figure 2: Responses regarding their own experience as pupils to the questionnaire on nature field trips.

CONCLUSIONS AND IMPLICATIONS

The prospective teachers agreed that nature field trips are an important activity in teaching and learning biology. In particular, there was strong agreement with:

(i) The relevance of these activities in enhancing the motivation of their pupils

(ii) The result for the pupil despite the effort involved in preparation.

(iii) Their essential role in the teaching and learning of Biology and Geology.

However, the respondents did not equally value these activities in recalling their own experience at school, and for many of the respondents nature field trips had been of no great relevance to their learning these subjects. The correlation analysis of these situations found no relationship between these expressions of poor nature field trip experiences as pupils and their consideration as future teachers. This may have been due to the reduced sample size, or to the teacher education process being followed by these prospective teachers which may in some cases have served to redress their unsatisfactory experiences as pupils.

The study has highlighted an important issue with respect to nature field trips in the teaching and learning of Biology and Geology. This concerns the potential mismatch that may arise between a teacher's expectations about the effectiveness of nature field trips and their actual positive influence on the pupils' learning (Figure 3). Further studies are therefore needed to analyze these situations, promoting actions that enable these activities to meet the expectations of the teachers who plan them, and to improve the learning process of the pupils. In this sense, an essential tool may be metacognitive programs of action research (Mellado et al., 2009).

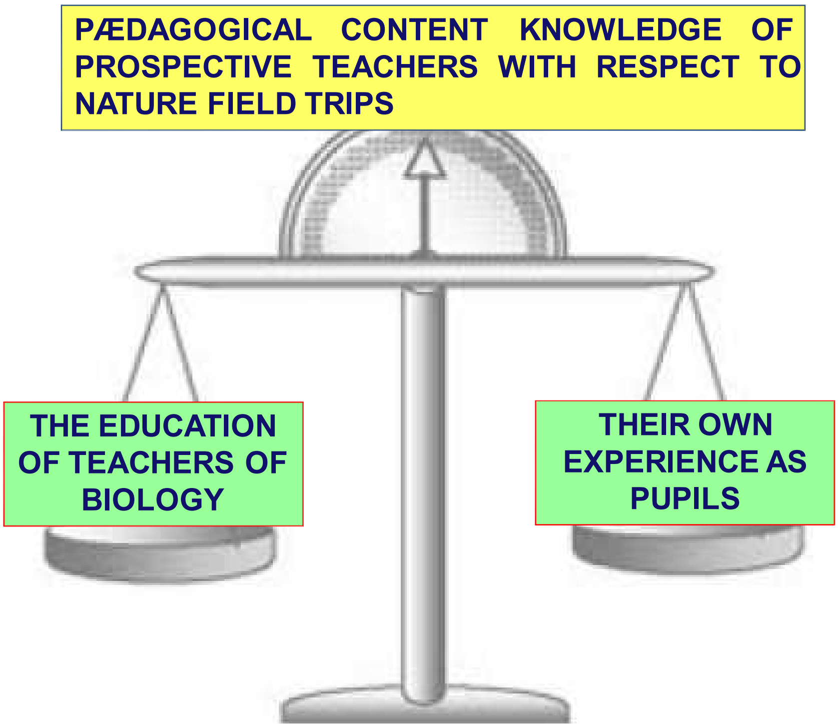

Figure 3: Potential mismatch in the prospective teachers.

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DEVELOPMENT OF CASE METHOD PROGRAM FOR TEACHER EDUCATION SUPPORTING THE CREATION OF LESSON PLANS

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Abstract: To create science lesson plans, teachers need to have not only science content knowledge and skills, but also ability to structure a curriculum and identify appropriate teaching methods and strategies to make the content comprehensible to students. Teachers also need the ability to identify expected students' actions and questions and to identify and incorporate 'how to respond to them' into the lesson plan. This study developed a case method program by using the *manga* textbooks for developing teachers' skills to create lesson plans. The program's effectiveness was evaluated through questionnaire surveys to program participants. From the results, this program was judged to be effective in developing the ability to create lesson plans.

Keywords: teacher education, case method, *manga*, lesson plan, science

1. INTORODUCTION

Fostering the next generation of teachers and developing their specialized knowledge, skills and competencies are major issues in teacher education. With regard to teachers' skills and competencies, the concept of pedagogical content knowledge (PCK) is widely known and has been extensively researched (e.g., Gess-Newsome & Lederman, 1999; Mishra & Koeher, 2006). Authors (2010) developed *manga* textbooks with a narrative approach to develop science teachers' skills and competencies, and evaluated the effectiveness of using those textbooks by conducting a survey with college students studying to become teachers. By using the *manga* textbooks developed by our project team, this study developed a case method program for developing teachers' skills to create lesson plans—the essential teacher skill of developing and conducting a lesson, and then evaluated the effectiveness of the program. The program's effectiveness was evaluated through questionnaire surveys to program participants, i.e., college students studying to become teachers. The evaluation was conducted from the following two perspectives: (1) college students' perceptions of the usefulness of the program, and (2) whether or not college students were able to create a lesson plan, giving enough consideration to children's expected actions and responses in the classroom.

2. THEORITICAL GROUND FOR THE USE OF *MANGA*

The theoretical grounds for using *manga* textbooks as a learning tool lie in the characteristics of *manga* as a medium; *manga* can be read and assimilated in a relatively short period of time, and messages to which the author wants to draw readers' attention can be embedded in pictures and words. Yoshikawa (2007) used *manga* textbooks with a narrative approach in MBA and other training programs in the field of business administration, and proved that *manga* textbooks are effective for developing learners' abilities to apply knowledge and skills to new contexts and in judging situations accurately. Yoshikawa suggested the possibility that *manga* textbooks can be used in various areas other than business, by adhering to the following six rules. The *manga* textbook developed in this study follows these six rules.

① Create an "event" in each scene that illustrates a key learning point.
② Embed pieces of information in a way that inspires readers to think about the event.
③ Create a context-dependent scenario, by establishing connections between an event and other events that had happened before that particular event.
④ Determine a theme for group discussion beforehand.
⑤ Create a focus point in each picture.
⑥ Determine what information should be expressed through words, what information should be embedded in pictures, and what information can be left implicit.

3. THE CASE METHID PROGRAM FOR TEACHER EDUCATION

To create science lesson plans, teachers need to have not only science content knowledge and skills, but also ability to structure a curriculum and identify appropriate teaching methods and strategies to make the content comprehensible to students. Teachers also need the ability to identify expected students' actions and questions and to identify and incorporate 'how to respond to them' into the lesson plan. However, the development of these skills and abilities cannot happen overnight; most of these skills/abilities are gained through experience.

The case method program for teacher education developed in this study is designed to enable users to simulate the execution of a lesson through a *manga* textbook that depicts, in a narrative way, actions and behaviors that students may perform during the lesson, and safety issues that relate to the lesson content. The topic of the lesson covered in the *manga* textbook

Figure 1.
Example of the manga textbook

used in this study was "how to operate a manual electric generator," which is covered in the lesson unit on energy (Figure 1). Problems embedded in the *manga* textbook were: 5 instruction-related problems, 3 problems with experimental techniques, and 4 lesson environment-related problems. Through this program, learners can develop their ability to accurately judge a situation, by engaging in solving problems as a main character of the story.

4. EVALUATION METHODS

The program's effectiveness was ev aluated from the following two per spectives:

(1) College students' perceptions of the usefulness of the program: A survey was conducted in April 2010 with 74 students of a women's college in Kyoto Prefecture who are studying to become teachers. After completing the program, the students answered a 4-point Likert scale questionnaire and a free response questionnaire. The Likert scale questionnaire contained a total of 14 items: 10 items regarding the effectiveness of the use of the manga textbook in learning how to develop a lesson plan, and 4 items regarding college students' impressions about the use of a manga textbook.

(2) Whether or not college students are able to create a lesson plan, giving enough consideration to children's expected actions and responses in the classroom: A study was conducted in August 2010 with 12 students of a national university in Hyogo Prefecture who are studying to become teachers. First, the college students were instructed to develop a lesson plan for a science lesson on a given topic (the topic covered in the manga textbook). Then they studied the manga textbook. After that, they made additions and corrections to the lesson plan they had created beforehand. By focusing on whether the college students gave enough consideration to expected children's actions and responses in the classroom, we examined "in which sections additions or corrections

were made" and "the contents of the additions/corrections made," from the three perspectives of instruction, experimental techniques, and lesson environment.

5. RESULTS AND DISCUSSION

From analysis of the results of the questionnaire regarding the program's usefulness (Table 1), it was found that all items received positive responses, which was statistically significant (p<.01).

Regarding sections of the lesson plan to which additions/corrections had been made (Table 2), most of the additions/corrections were made in the section of "important points for teaching" Analysis was also performed on the numbers of college students who made or did not make additions/corrections by perspective, using the direct probability calculation method. As a result, statistically significant differences were observed regarding instruction and experimental techniques (p<.05); no statistically significant differences were found regarding lesson environment (*n,s*). Judging collectively from these results, it can be concluded that college students recognized the importance of the ability to predict children's difficulties and possible actions in preparing a lesson plan, as well as the necessity of acquiring good teaching and experimental skills.

Table 1. Questionnaire items and results

	Item	Students who aim to become elementary school teachers		
		YES	NO	
1	This textbook enables effective learning of lesson plan development.	74	0	**
2	This textbook is easy to use, and explanation in the textbook is easy to understand.	72	2	**
3	The instructional method that engages learners in group discussion, using a textbook, was effective.	74	0	**
4	This textbook is useful for individuals aiming to become teachers.	74	0	**
5	I could understand the relationship between the organization of the lesson plan and the lesson.	72	2	**
6	I understood the difficulty of executing the lesson as planned.	74	0	**
7	I understood the importance of the lesson plan for effective teaching.	74	0	**

8	The textbook was useful for me to understand how to write a lesson plan.	73	1	**
9	I understood how to read a lesson plan.	73	1	**
10	I understood that the lesson plan is an effective tool for communicating the lesson content and teaching methods used in the lesson.	74	0	**
11	I understood that it is important to create a lesson plan, predicting what will happen during the lesson.	74	0	**
12	To create a lesson plan, it is necessary to understand pupils' attitudes and learning abilities.	74	0	**
13	I think that this learning experience will be of help in creating lesson plans in the future.	74	0	**
14	I want to read a *manga* textbook that deals with lesson plan development, if it exists.	74	0	**

Table 2. Modified parts of the lesson plan

	Added and corrected sections			Added and corrected perspectives		
	Lesson content	Student activities	Important points for teaching	Instruction	Experimental techniques	Lesson environment
Total	1	3	12	11	10	8

6. FUTRE TASKS

This program was judged to be effective in developing the ability to create lesson pla ns. The plan is to develop more case method programs to accommodate learners' vary ing levels of lesson plan development skills and to conduct surveys to investigate the effectiveness of the developed programs.

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JORDANIAN CHEMISTRY STUDENT TEACHERS' AND EXPERIENCED TEACHERS' BELIEFS ABOUT TEACHING AND LEARNING

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Abstract: This poster presents an exploratory study of Jordanian chemistry student teachers` and experienced teachers' beliefs about teaching and learning. As method we used teachers' and students' drawings of teaching situations accompanied by four open questions. Data was evaluated by a grid describing teachers' Beliefs about Classroom Organization, Beliefs about Teaching Objectives and Epistemological Beliefs. For validation, a second evaluation using the same data source is made by applying the 'Draw-A-Science-Teacher-Teaching'-Checklist (DASTT-C), which shows the teacher- or student-centeredness of teachers` beliefs concerning science teaching. The results indicate that both above-mentioned groups hold quite traditional beliefs, which are teacher- and content-centered when it comes to chemistry teaching practices. Student teachers profess ideas which are even more pronouncedly traditional.

Keywords: chemistry education, teachers' beliefs, DASTT-C

FRAMEWORK AND OBJECTIVES

Teachers´ beliefs have recently gained increased attention in both general educational research (Munby, Russell & Martin, 2001) and in science education (De Jong, 2007). Studies focusing on both in-service (Woolley, Benjamin, & Woolley, 2004) and pre-service teachers (Bryan, 2003; Richardson, 2003). Such studies provide promising approaches to better understanding teachers' learning processes and behavior in class (Nespor, 1987). Evidence of student teachers' beliefs is also valuable for teacher trainers, who can map out currently-held ideas about teaching and learning, then see how they can be applied and/or changed (Nisbett, 1980). Such knowledge shows potential for improving university teacher education programs in order to better facilitate candidates' personal learning and professional development (Bryan, 2003). Finally, research on beliefs is seen as useful for curriculum innovators and planners, who can more effectively implement curriculum changes by taking existing teachers` beliefs into consideration (De Jong, Veal & Van Driel, 2002).

From previous research we know that different factors influence and shape existing teachers` beliefs, including teacher's own learning experiences in school, educational background, the quality of pre-service experiences in class, opportunities for self-reflection (or the lack theory) during pre-service training, and the influence of discipline-related and domain-specific subject matter training (Goodman, 1988; Markic & Eilks, 2008). The larger context of national policies and the context of cultural norms and values also play an important role in affecting teachers` beliefs (Isikoglu, Basturk & Karaca, 2009). Markic and Eilks (2008) have demonstrated the influence of educational domain and the level of education on the formation of educational beliefs. In their study on freshman student teachers in Germany, primary school science and secondary biology teacher trainees showed themselves to be very student-centered in their beliefs and approaches. Their colleagues with a comparable educational and cultural background preparing to teach secondary school chemistry and physics proved to be much more teacher-centered, holding extremely content structure-driven beliefs.

Increasing numbers of studies about teachers' beliefs are now being published. Starting from trainees' general educational beliefs, Van Driel, Bulte and Verloop (2007) were able to distinguish between two different ideologies which form a continuous dimension visible within various beliefs studies. The first ideology has been called *teacher-centered* (Bramald, Hardman, & Leat, 1995) or, alternately, *subject-matter oriented* (Billig, Condor, Edwards, Gane & Middleton, 1988). On the opposite end of the spectrum we find the *personal* (Shen, 1997), also called *student-supported* (Trigwell, Posser, & Taylor, 1994) or *learner-centered* (Bramald et al., 1995) learning. Markic and Eilks (2008) suggest viewing this spectrum as a range between traditional beliefs (transmission-oriented beliefs of learning with a focus on pure subject-matter knowledge) and modern beliefs (beliefs based on constructivistic learning, student-oriented classroom structures, and an orientation on more general educational skills, including Scientific Literacy for all). This dichotomy is in line with e.g. Thomas, Pederson and Finson (2001) or Van Driel et al. (2007), or Qablan, Jaradat and Al-Momani (2010) for curriculum reform in Jordan what is the background of this study. Unfortunately, evidence concerning secondary chemistry (student) teachers' beliefs about teaching and learning in Jordan is scarce in the literature.

Currently, the country of Jordan is going to great efforts to develop and expand its educational system (Jordan Ministry of Education, 2010). Many reforms have already been elaborated upon and tested. However, teachers' beliefs are not included in the focus of these innovations, whose implementation remains unsatisfactory (Qablan et al. 2010). The purpose of the current study was, therefore, to investigate different aspects of chemistry (student) teachers` beliefs about secondary chemistry in order to pinpoint any differences between Jordanian in-service and pre-service teachers. The focal points selected were quite general. They dealt primarily with achieving a general overview of chemistry teachers' beliefs about teaching and learning, the aims and objectives of chemistry lessons, and classroom culture and activities.

This study attempts to answer the following questions:

1. What beliefs do Jordanian teacher trainees and in-service teachers hold regarding chemistry teaching and learning, including student- and teacher-centeredness, overall teaching objectives, and understanding the learning process?
2. What are the similarities and/or differences in beliefs about teaching and learning for these two groups regarding the above-mentioned fields?

METHOD AND SAMPLE

The study is based on a modified version of the "Draw-A-Science-Teacher-Test Checklist" (DASTT-C). The original DASTT-C (Thomas, Pedersen & Finson, 2000; 2001) requests the participant to draw oneself and the learners in a typical classroom situation. The drawing is followed up by two open-ended questions about the activities of teacher and students. Markic, Eilks, and Valanides (2008) added another two open-ended questions to this to gain a more detailed overview of the situation. The added questions inquire into the teaching and learning objectives of the situation depicted and the approach chosen towards the drawn situation.

A first evaluation was done by an evaluation grid developed by Markic et al. (2008). This grid categorizes a range stretching from traditional beliefs to more modern beliefs in line with current educational theory. The evaluation pattern analyzes participants` beliefs in three qualitative categories: 1) *Beliefs about Classroom Organization*, 2) *Beliefs about Teaching Objectives*, and 3) *Epistemological Beliefs*. Each category was evaluated using a range from -

2 to +2 to describe beliefs in the above-mentioned dimensions along an ordinary, but non-linear scale (Markic et al., 2008). Data was encoded by two independent raters. The agreement rate was continuously above 80%. In cases of disagreement, joint rating was carried out by searching for inter-subjective agreement (Swanborn, 1996).

Table 1: An overview of the scales in the qualitative part of the study (Markic & Eilks, 2008)

	Traditional beliefs		*Modern beliefs*
Beliefs About Classroom Organization	Classroom activities are mostly teacher-centered, -directed, -controlled and dominated by the teacher.	↔ -2, -1, 0, 1, 2	Classes are dominated by student activity and students are (at least partially) able to choose and control their activities.
Beliefs About Teaching Objectives	The focus of science teaching is more-or-less exclusively focused on content learning.	↔ -2, -1, 0, 1, 2	Learning of competencies, problem solving or thinking in relevant contexts are the main focus of teaching.
Epistemological Beliefs	Learning is passive, top-down and controlled by the dissemination of knowledge.	↔ -2, -1, 0, 1, 2	Learning is a constructivistic, autonomous and self-directed activity.

For validation, this study also applied the original pattern from the “Draw-A-Science-Teacher-Test Checklist” (DASTT-C) by Thomas et al. (2000; 2001). In DASTT-C, the drawings and open-ended questions are evaluated using a checklist. The total score depends on the presence or absence of thirteen attributes in three main areas: the teacher, the students, and the environment. The complete checklist can be found in Thomas et al. (2000). The presence of any of the thirteen attributes within a section is scored with a "1", an absence with "0". Thus, the total score can fall between 0 and 13. Scores of 0-4 indicate student-centered teaching, while values between 7 and 13 represent teacher-centeredness, no decision is made for scores of 5 or 6 (Thomas et al., 2000). The data was rated by two independent raters; inter-rater reliability was moderately high ($\kappa = 0.74$ for teachers and $\kappa = 0.76$ for student teachers).

The sample consisted of 23 student teachers (13 male and 10 female) and 44experience teachers (25male and 19 female).

RESULTS AND DISCUSSION

Examples from the sample are given in Figure 1. Figure 3a represents an example of teacher-centered beliefs. The teacher in Figure 3a appears in the center of classroom activity. The students are either responding to the teacher by answering his questions or simply listening to him; the blackboard is the focus of all student attention. This classroom is a traditional one without any indicators of student activity (experimental equipment, etc.). The drawing in Figure 3b gives a student-centered viewpoint showing students in the lab performing an experiment. Typical teacher-centered indicators are not present, for example, the teacher standing in the center of the classroom or media centralizing the students’ attention.

In the first data interpretation (Figure 2) the *Beliefs about Classroom Organization* show strong tendencies towards teacher-centered beliefs can be recognized in both groups. Over 90% of the student teachers and almost 80% of experienced teachers described a classroom dominated by the teacher, where student activity plays only a minor role and is completely dominated by the teacher. The same can be said for *Beliefs about Teaching Objectives*. A dominant majority (about 80%) of student teachers expressed traditional beliefs about the objectives of chemistry lessons. The more-or-less exclusive goal of chemistry lessons in their estimation is the learning of subject-matter content. This is in line with Qablan et al. (2010), whose findings described Jordanian primary school teachers' attitudes towards educational reform who discussed reforms primarily by referring to developments in more effective methods of pure knowledge transfer. The same can be said for the group of in-service chemistry teachers in the present study as well. By the number this group is being a bit less extreme but the tendency towards the most strongly traditional beliefs was more pronounced in a group as a whole. For *Epistemological Beliefs* both groups draw situations with chemistry teaching being quite strongly as a transmission of knowledge organized by the teacher (scores “-2” and “-1”). About 70% of the student teachers expressed strong traditional beliefs about teaching (score “-2”). The in-service teachers were not as traditional as the student teachers in this regard. The majority received a score of “-1” in this category, which can be interpreted as being "rather transmission-oriented". No student teacher professed beliefs which could be rated as either modern or quite modern; even among experienced teachers there were only about 5% (scores “2” and “1”) of participants who expressed relatively modern ideas.

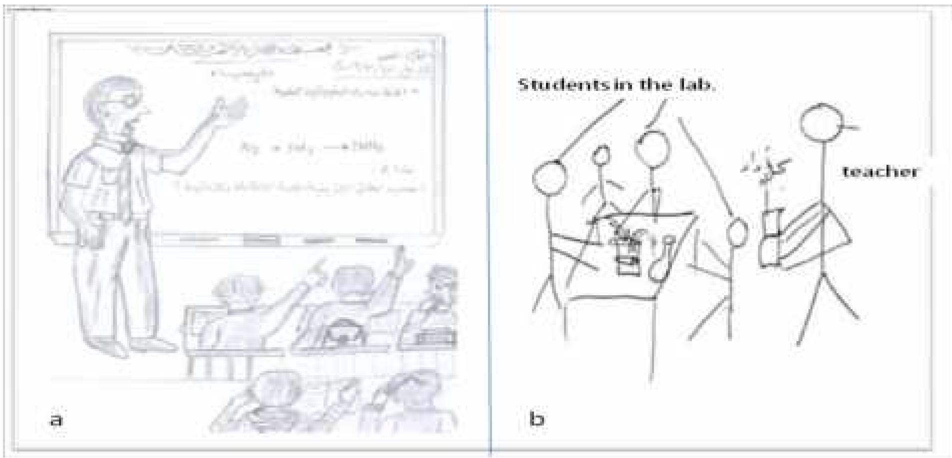

Figure 1. (a) Traditional/teacher-centered and (b) modern/student-centered drawings of two Jordanian teachers

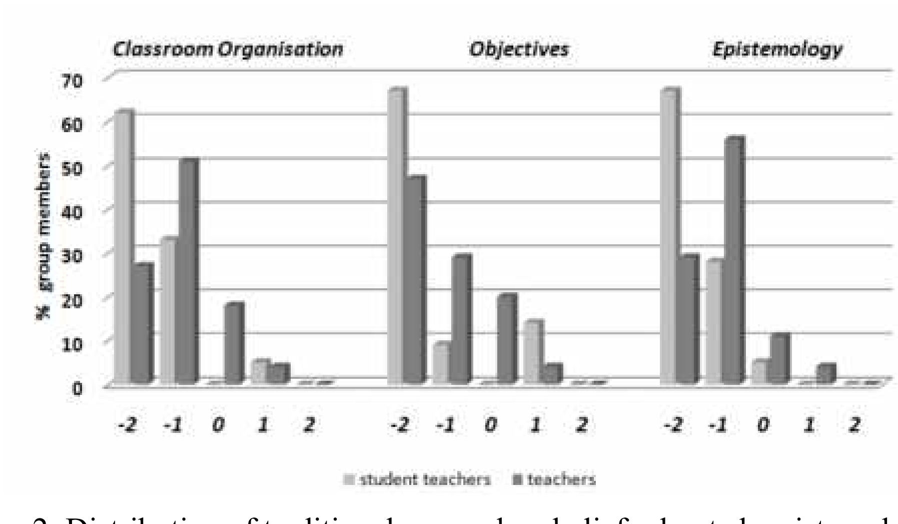

Figure 2: Distribution of traditional vs. modern beliefs about chemistry education

If a teacher has similar replies in each of the three categories, the combination of codes will appear on or near the diagonal stretching from (-2/-2/-2) to (2/2/2) (Markic & Eilks, 2008). The closer a given code combination comes to the upper, right, back part of the 3D-diagram, the closer these beliefs are to modern educational theory. Conversely, code combinations appearing in the lower, left, front part of a 3D-diagram represent more traditional beliefs. Jordanian student teachers in general hold very traditional beliefs. The ideas expressed by experienced, in-service chemistry teachers show more scattering, but also evidence a tendency towards more traditional beliefs. Both groups professed more-or-less strongly teacher-centered, content-structure, and transmission-oriented beliefs (Figure 3).

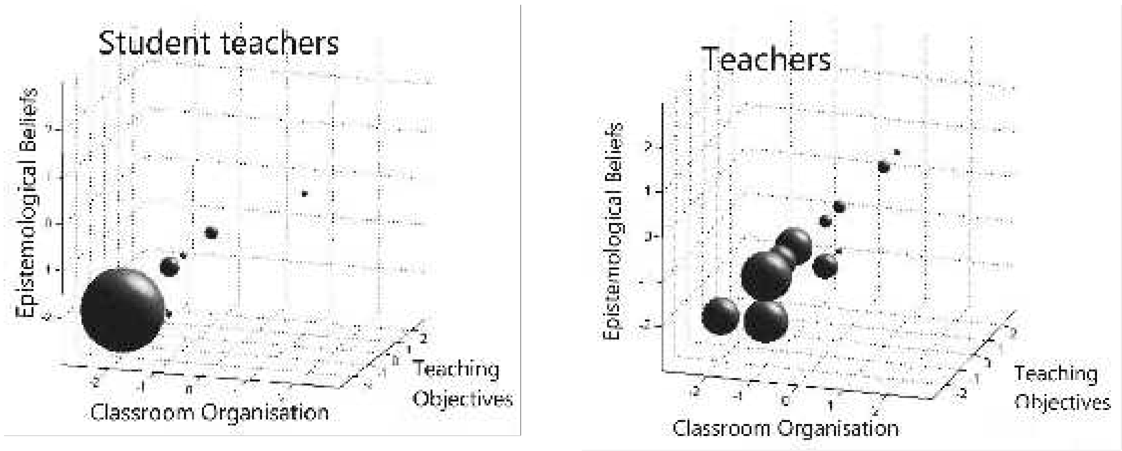

Figure 3: 3D-representation of the data

Figure 4 present the validating results of applying the checklist from Thomas et al. (2001). Also here teachers and student teacher both hold predominantly teacher-centered beliefs. 87% of student teachers fall into the teacher-centered area (a score of 7-13). The majority of experienced teachers also achieved scores of 7-13, but this group is 70% smaller than that of the student teachers. Only 4% of student teachers and 16% of the in-service teachers attained a score which characterized them as being student-centered.

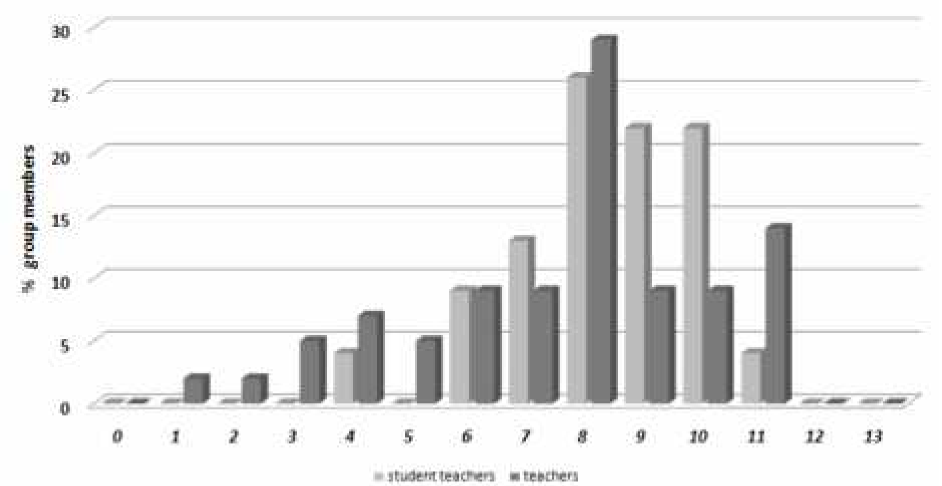

Figure 4. Distribution of student and in-service teachers according to DASTT-C

CONCLUSIONS

Both Jordanian in-service teachers and student teachers hold very traditional beliefs when it comes to teaching and learning chemistry. Such traditional beliefs can be characterized by teacher-centeredness, a transmission-oriented understanding of learning, and a strong focus on the pure learning of subject-matter. A second observation is that student teachers' beliefs tend to be much more traditional than those of experienced teachers. This might stem from the fact that Jordanian chemistry teachers attend only a workshop-based training program, and having no long-term based practice oriented courses during teacher education.

Nevertheless, beliefs and ideas expressed about chemistry teaching practice still remain very traditional. Only in rare instances are they connected with modern, theory-driven characteristics of chemistry education. Reasons for this might include the lack of appropriate in-service training in Jordan, the content level of courses offered, the amount of total training available and an extremely short training duration of only one year. Strongly bottom-up teacher training programs, e.g. those found in Germany, have already shown that substantial and sustainable changes are possible in the long run by combining educational courses with domain-specific education (Markic & Eilks, 2011). Another important consideration is that nearly all of the student teachers expressed very strong, traditional beliefs. These beliefs have mainly been constructed due to their previous experience as learners in school and university. This yields a picture of the prevalent practices in the Jordanian educational system which demands more self-reflection on these practices using the lens of modern educational theory.

The situation described here demands innovations in teacher training. This falls in line with Oliamat (2009), who recommended a more thorough concentration on the elaboration of teacher training programs to develop both teachers' pedagogical knowledge and teaching practices. Systems and structures are notoriously hard to change. Perhaps it would be easier and more effective to simply change the content within already existing courses. The workshops should be optimized to more thoroughly content prospective teachers with concrete student-active methods, instructional tools and illustrating examples for the domain-specific learning environments they later on will work in. But the teachers and student teachers also need tools and competencies to reflect upon teaching objectives in the sense of scientific literacy, or different approaches to constructivistic learning. A promising starting point might be an initial reflection upon one's *a priori* beliefs about teaching and learning. A self-reflection session focusing on the question of teacher- or student-centeredness often helps to plant the seeds of change. As suggested in Markic and Eilks (2008), tools like DASTT-C (or its modified version) can readily and easily applied for this purpose.

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PRE-SERVICE CHEMISTRY TEACHERS' UNDERSTANDING OF ELECTROLYTIC CELLS

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Abstract: The purpose of this study was to investigate pre-service chemistry teachers' understandings and misconceptions regarding the electrolytic cells in electrochemistry. The sample of this study was composed of 31 pre-service chemistry teachers in chemistry teacher education program in Turkey. Data was collected via seven open-ended questions related with electrolytic cells. Two researchers analyzed written responses of participants independently, then came together and discussed the answers to reach consensus. Results revealed that pre-service chemistry teachers had difficulty in understanding of electrolysis and most of them could not distinguish electrolytic cells from galvanic cell. Also, they could not identify the electrodes as anode and cathode in electrolytic cells, so they could not predict the product of the electrolysis correctly. It can be concluded from the results of this study, pre-service chemistry teachers had misunderstanding regarding both galvanic and electrolytic cells. Misconceptions and conceptions of pre-service chemistry teachers should be detected and remedied in this topic in teacher education programs so they can educate their students effectively regarding electrochemistry topic in future.

Keywords: pre-service chemistry teachers, electrochemistry, electrolytic cells, misconceptions, teacher education

BACKGROUND, FRAMEWORK, RATIONALE, AND PURPOSE

Electrochemistry has been regarded as one of the most difficult chemistry topics in which both pre-service teachers and students have learning difficulties (Nakhleh, 1992; Ogude & Bradley, 1994; Sanger & Greenbowe, 1997a). A number of researchers investigated students' and teachers' misconceptions in electrochemistry topic (Doymus, Karacop & Simsek, 2010; Garnett & Treagust, 1992a, 1992b; Ogude & Bradley, 1994; Özkaya, 2002; Sanger & Greenbowe, 1997a, 1997b). Garnett and Treagust (1992b) investigated high school students' understanding of electrochemistry in terms of electrochemical and electrolytic cells and identified students' misconceptions in these topics and possible sources of these misconceptions. In 1997, Sanger and Greenbowe replicated the study of Garnett and Treagust (1992b) with college chemistry students and found similar findings with them as students had learning difficulties and misconceptions in galvanic, electrolytic and concentration cells. Moreover, Sanger and Greenbowe (1997a) emphasized that identifying misconceptions was important to help learners understand this topic meaningfully. Although there have been studies on conceptions of students about electrochemistry topic at high school level, studies conducted with pre-service teachers are few (Ogude & Bradley, 1994; Özkaya 2002).

Therefore, this study investigated pre-service chemistry teachers' understandings and misconceptions regarding the electrolytic cells in electrochemistry. The research question of this study is presented below:

What are the conceptions of pre-service chemistry teachers regarding electrolytic cells in electrochemistry?

METHODS

The sample of this study was composed of 31 pre-service chemistry teachers (PCT) in chemistry teacher education program in a state university in Turkey. Data was collected via open-ended questions. Seven open-ended questions were designed by researchers in the light of related literature (Garnett & Treagust, 1992b; Sanger & Greenbowe, 1997a). Suggestions of four experts in chemistry education were taken into consideration while developing the questions. Each participant was asked the following open-ended questions:

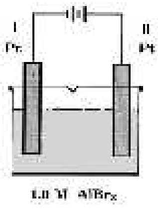

Figure 1

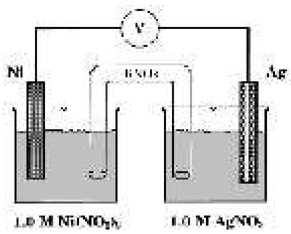

Figure 2

"Please answer these questions considering the electrolytic cell given in Figure1.

1. How does Figure 1 differ from Figure 2? Explain.
2. How would you determine which electrode is the anode and which is the cathode?
3. In which direction do the charges flow in this cell to complete the circuit?
4. What reactions are taking place at each electrode?
5. Compare the mass of electrodes before and after the reaction. Please explain your answer.
6. Can you predict the E value for this set-up?
7. Suppose the solution was changed to molten $AlBr_3$, would you expect happen any differences? Explain your ideas."

Qualitative content analysis (Creswell, 2009) was used in order to analyze the data. Firstly, two researchers analyzed written responses of PCT independently, then came together and discussed the answers to reach consensus.

RESULTS

Results of the study indicated that half of the participants gave irrelevant responses to the question asking the difference between galvanic and electrolytic cells. They stressed the differences such as electrolytic cell has no salt bridge, it has one type of solution, and the electrodes are the same. On the other hand, participants who responded the question correctly claimed that in galvanic cells the reactions are spontaneous while in electrolytic cells they are nonspontaneous.

Only six out of 31 participants were successful to determine the anode and cathode of the electrolytic cell by using the polarity of the battery. On the other hand, sixteen wrote incorrect responses. Three of them used standard reduction potentials to identify anode and cathode. For instance, one participant wrote "*I will determine anode and cathode by using standard electrode potential. The substance which has the higher potential will reduce; the other one will be oxidized.*" Five participants who gave incorrect responses to this question claimed that the reactions occurring at electrodes will identify whether the electrode is anode or cathode. For instance, one participant wrote that "*The electrode in which oxidation reaction occurs is anode, the other one is cathode.*" In addition, one of the participants who responded this question incorrectly claimed that as the electrodes were in the same beaker and made from the same metal, so any of the electrodes may be anode or cathode. For instance, one of the participants explained this situation as "*both of the electrodes are made up of platinum so either of them can be anode or cathode*." The rest of the participants' responses were evaluated as trivia or no answer. These results indicated that most of the PCT did not know the function of the battery used in electrolytic cells in terms of determining anode and cathode.

Ten out of 31 participants could correctly state the direction of electron flow. Other participants either did not state the direction of electron flow or state that it would be from anode to cathode although they could not identify where the anode and cathode were. Moreover, considering the flow of other charges, six participants stated that cations would go to cathode while anions would go to anode and did not consider that water could be oxidized or reduced.

None of the PCT could correctly predict both $H_{2(g)}$ and $Br_{2(g)}$ as the products of electrolysis. One of them stated that H_2O would reduce at cathode, however could not predict the product correctly. While six of them stated that $Br_{2(g)}$ would occur at anode, $Al_{(s)}$ would occur at cathode instead of $H_{2(g)}$. This result suggested that PCT ignored the reduction of H_2O and thought that the cation (Al^{+3}) in the solution would reduce. This point of view led these PCT to think that while the mass of cathode would increase due to precipitation of aluminum at cathode, the mass of anode would not change due to the formation of $Br_{2(g)}$. Also, four PCT stated that while the mass of cathode increases, the mass of anode decreases likewise it generally occurs in galvanic cells. This result indicated that these PCT had incorrect idea regarding Platinum metal as reactive. The rest of PCT could not respond the question related with the changes in mass of electrodes.

The question related with E value for electrolytic cell was correctly responded by only six PCT as $E < 0$. Five of PCT responded this question incorrectly as $E>0$. These participants were not aware of the fact that in electrolytic cells nonspontaneous reactions occur. The rest of the participants did not respond the question.

The last question was correctly responded by only one participant as the product of electrolysis of $AlBr_{3(l)}$ would be $Al_{(s)}$ and $Br_{2(g)}$. While six participants could not respond this question others gave incorrect responses to it. For instance; some of them claimed that as $AlBr_{3(l)}$ was not formed of ions it could not be electrolyzed. Also some participants claimed that as the concentration of $AlBr_{3(l)}$ was greater than $AlBr_{3(aq)}$ reduction reaction would occur more easily.

CONCLUSIONS AND IMPLICATIONS

The results indicated that PCT had difficulty in understanding of electrolysis and they have incorrect knowledge regarding this topic. The misconceptions concerning electrolysis detected in this study were consistent with students' misconceptions presented in previous studies in the literature (Garnett & Treagust, 1992b; Sanger & Greenbowe, 1997a). Most of the PCT could not distinguish electrolytic cells from galvanic cell and this led PCT to have misconceptions such as they thought electrodes would react even they were made up of platinum or the battery has no effect on the site of the anode and cathode. Furthermore, due to not identifying the electrodes as anode and cathode, they could not predict the product of the electrolysis correctly. It can be concluded from the results of this study, PCT had misunderstanding regarding both galvanic and electrolytic cells. In the light of the findings, this study has some implications. Misconceptions and conceptions of PCT should be detected and remedied in this topic in teacher education programs. To clarify, distinction between galvanic and electrolytic cells should be discussed as well as discussions about important concepts in electrolytic cells can be beneficial for prospective teachers to be aware of their conceptions. It is important to graduate prospective teachers with sound understanding of electrochemistry topic like other chemistry topics. Hence, they can educate their students effectively regarding electrochemistry topic in future.

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THE USAGE OF VISUALIZATION IN CHEMISTRY TEACHING AND PRE-SERVICE EDUCATION: SOME FINDINGS

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Abstract: This study is a qualitative research where we try to find out and analyze the conceptions of pre-service teachers (n=24) of a Chemistry class from University of São Paulo (USP), São Paulo, Brazil, about the usage of visualizations in chemistry education. In order to reach our aims in the beginning a questionnaire was applied to all the class and at the end of the semester two groups of seven pre-service teachers were chosen to apply a semi-structured interview that focused their own choices and the use of visualizations as teachers in a mini-course that they presented to middle school pupils at São Paulo University. The speeches analysis (questionnaire, interviews and mini-course reports) was done based on the Michel Foucault's contribution to speech analysis. As a result of this study we highlight that the theoretical conceptions of these pre-service teachers are superficial, not solid, and sometimes even become misconceptions. The speech of these pre-service teachers on visualizations presents as main referent the abstract nature of chemical concepts and the capacity that this resource has to make chemistry classes more interesting, to keep students attention and to make chemistry concepts close to quotidian. We also found in these statements the presence of their college, the practices of their own teachers and the IT industries. The choices on visualizations and the way that they used these tools were strongly related with the presented referents, specially with their capacity to keep attention, to increase the class interest, or the capacity to make chemical concepts more close to the reality and/or quotidian.

Keywords: chemistry teaching, pre-service teacher's education, visualization

INTRODUCTION

Models and the role of visualization in science and science education, especially in chemistry, have grown up during the last decade. Chemistry involves the interpretation of matter observables changes (e. g. color changes or gas release) on the macroscopic level in terms of imperceptive changes on the submicroscopic level. These changes are represented in a symbolic and abstract way using symbols, equations, graphics, etc. With the purpose of making these representations accessible to the students, teachers are using visualizations more frequently. The accelerated development of information and communication technologies followed by several studies in the cognitive theory area, have promoted the construction of many visual tools (3D concrete models, virtual 2D and 3D images, simulations, animations, interactive software, etc.) that have been placed to the disposition of educators. With the frequent use of these tools, images became the main vehicle of information, and if the learning impact is bigger so is the risk of misconceptions if the choice of the image is inappropriate. Progressively educators began to recognize the value of the visual component on the chemical knowledge, which was until then, only attributed to the verbal and mathematical language; nevertheless the pictorial chemistry language is by itself a higher structured language (Ege, 1994). With Jonhstone (1991) the chemical knowledge was divided in three levels of representation (submicroscopic, macroscopic and symbolic). For a student immersed in the macroscopic world, the reality, it becomes very difficult for him to

understand the concepts and the processes located at the submicroscopic level and represented in the symbolic language of chemistry. There is a stead growing body of research that suggests that the use of visual tools helps students' transition between these levels of representation.
Reviewing the literature we found that there are three common academic usages of visualization in psychology and educational research (Gobert, 2007): external visualization, internal visualization and visualization as a type of spatial skill. In a simple way we can say that external visualizations in science refer to graphics, diagrams, models, simulations, etc, representations typically used in learning; internal visualizations are used to describe internal mental constructs, i.e., mental models; and visualization is also used to describe a type of spatial skill, the ability to manipulate or transform the image or spatial patterns into other arrangements. Also, according to Gilbert et al. (2008) a central topic that often crosses these studies is the definition of the term "visualization". There are two conventions, in convention 1, visualization is a verb (to visualize something is to mentally act on it), in convention 2 visualization is a noun (visualization is something in the public realm). Inevitably, there are also studies that cross the two conventions, for instance, studies about "visuospatial thinking".
We found literature approaching this issue in the sense of convention 1 that dealt with questions such as: How is a visual representation turned into knowledge? What are the mental processes involved in attaching a meaning to a representation? What mental and brain processes are involved in "seeing"? (Reiner, 2008). Other authors (Gilbert, 2007; Rapp & Kurby, 2008; Briggs & Bodner, 2007) also present their ideas about these concerns. Gilbert refers the importance of developing "metavisual capability" or "metavisualization", the acquisition of fluency in visualization and the making of meaning for any representation (Gilbert, 2008). This author suggests that this development could be done by general good practice in the use of representations by teachers and in textbooks and by the specific cultivation of the skills involved (Gilbert, 2007). For Gilbert the skills involved are: being able to move fluently between two-dimensional and three-dimensional representations of a given model (translate); being able to mentally change the perspective from which a given three-dimensional representation is viewed (rotation); being able to operate on the representation itself, particularly in terms of taking mirror images of it (reflection and inversion).
Like we mentioned before, there is another trend of research that uses the term visualization in the sense of convention 2, a noun, something that has been placed in the public realm in either a material object, visual, verbal or symbolic form. Here we found several studies (Wu, Krajcik & Soloway, 2001; Ferk et al., 2003; Santos & Greca, 2005; Tasker & Dalton, 2006; Kozma & Russell, 2007; Arroio & Honório, 2008) that by using a different approach try to evaluate the use of different kinds of visualizations in chemical instruction. Most parts of these studies are only quantitative and through a series of specific tests they try to evaluate the pupil's apprenticeship and indirectly the effectiveness of the visualization used.
In a literature review on this area we found some recent studies (Justi & Gilbert, 2003; Justi & Driel, 2005) that investigate the teacher's views/knowledge on the nature of models and modelling that point out the need to work these concepts in pre-service and in-service education. In their research they found teachers with less than satisfactory understanding of the nature of "model" which has implications on their teaching approaches on this concept.
With the development of this investigation we try to identify and analyze the conceptions of pre-service teachers (n=24) of a Chemistry class from University of São Paulo (USP), São Paulo, Brazil, about the use of visualizations in chemistry education. The data analysis was done based on Michel Foucault (2000) contributions about speech on educational field. Foucault analyzes the discursive and practical conditions for the existence of truth and meaning. The statements are 'events', because, like other rules, they appear at some time.

Statements depend on the conditions in which they emerge and exist within a field of speech; the meaning of a statement is reliant on the succession of statements that precede and follow it. So, as a historical method, the analysis of the statements is done in a historical context: the discursive formation. This author also attributes a mutual conditioning between the speeches practices and the none-speeches practices, which we consider very relevant on this work. As we are going to see the way they use these tools is strongly related with the conceptions they have on models and visualization.

METHODOLOGY OF RESEARCH

We used a qualitative research in our study, applying a questionnaire and a semi-structured interview to a class of 24 graduates of a chemistry education course of São Paulo University (USP), Brazil. These pre-service teachers (undergraduate) had a range of academic backgrounds, but the most important is that 8 of them had no experience in teaching, but the other 16 had already some teaching experience. We applied a questionnaire with 17 open-ended questions seeking to know what conceptions about visualization, use of models and images they possess, and at the same time what was the contribution of their graduation on this issue. We also want to know if they felt that they are prepared to teach in this new teaching environment. During the Chemistry Teaching Methodology II class, these pupils had to prepare a mini-course to offer to middle school pupils. This mini-course takes two days, and these graduates are responsible for the entire mini-course (subjects, methodology, assessments). At the end of this mini-course we applied an interview on two groups of seven graduates with several questions. The first set of questions (nine questions, common in both interviews) were more general and aimed to know what conceptions they had on visualization and it's use, the next questions (three for the first group and four for the second group) were about their own choices on the visualizations used in their mini-course classes. We also analyzed their mini-course reports.

The speeches analysis of their statements was done, as mentioned before, with Michael Foucault's contributions. According to this author each statement can be characterized by four basic elements: a referent, a reference to something that we identify, the person, someone that assert something (in the sense "of position" to be occupied), an associated field (the statement doesn't exist isolated, but always associated to other statements, from the same speech or from other speeches), and finally a specific materiality, the concrete forms where he appears (oral speech, write speech, tapped things that can be reproduce through practices and social relationships) (Fischer, 2001).

RESULTS OF RESEARCH

According to the chosen theoretical framing, the speech of these pre-service teachers on visualizations presents as main referents: the abstract nature of chemistry concepts, the capacity that this resource has to make chemistry classes more interesting, "*to break the monotony"* or to keep students attention, and to make chemistry concepts close to quotidian. Only a few made some references to their educational value, and these references were found mostly in the questionnaire, on practice they used them specially in order to get and keep student's attention and to discuss prior knowledge. We also found on their statements references between these tools and the realism that they confer to the objects of the submicroscopic chemical dimension. This was very clear, for instance, when they introduced an animation in the class "*Let's see what happens when we put salt on water*."

Pursuing our speech analysis we must characterize the person. Who speaks? What is the status of these students? Where they got this speech? Where they put into practice? The person of these speeches is a student from a university, considered the best of South America, who already takes a position as a teacher (majority) in the Brazilian school. He is a last year graduate from the chemistry education course, whose curriculum presents a division between pedagogical subjects and specific-contents subjects, so the discussion of the theoretical issues related to the use of these tools isn't yet effective. The recurrent use of these tools requires a good practical knowledge (technical knowledge) interconnected with a theoretical background in order to allow teachers to find adequate pedagogical solutions to its use. When they were asked to explain their choices of visualizations they show a weak theoretical knowledge about this issue, they expected as they said, "*the images made their role*", and if everybody uses them, so they must be important for learning. So, the person of this speech is mainly a teacher who the society began to make available a set of visual tools and demand its use in a classroom without the necessary education. So, in practice we have a teacher who makes a none-reflected use of these visual tools, where image is a source of entertainment; these conceptions arise in an imagetic culture. The influence of the media grasps all the social classes and institutions, among those, school, and especially chemistry teaching. They get this speech mainly in the school through the speeches and practices of their own teachers about the use of visualization, on the papers and books about this issue, and on the governmental policies in the education field that encourage and promote the use of these visual tools. That's also in their university that this speech appears, talking with their teachers and their colleagues, on their practices, reports, tests, etc. They also spread this speech as teachers on their schools.

Featuring the associated fields that appears in the statements of this future graduates in chemistry teaching about visualization's use, we found a set of statements deriving, for instance, from pedagogy: "*To arouse student's interest, keeping them concentrate in classroom allowing him to develop abilities and perceptions about the macro and submicroscopic world of chemistry*." Or from didactics, the use of these tools appears related with the need to convert the chemical concepts in school contents. We can see on their statements the presence of the IT industries (none-speech domains), "*We have a salt dissolution, we must use an animation, it has to be, something dynamic, it has to be…*". Nevertheless, as we said before, we found a great number of references from the media field, such as "*The idea was to impact the audience*.", "*The color keeps the attention*". In order to finish the analysis of this speech, we must characterize the materiality of these statements. These statements appear on the written answers to a questionnaire, on the assessments reports of the mini-course and on the interviews that they gave to this research. This status indicate that they are data for a research and they are going to be a part of the literature about this subject, they are going to circulate in the academic field, they will be decomposed, manipulated and eventually destroyed.

DISCUSSION

The result obtained in this sample is coherent with several studies (Gilbert, 2007; Ferk et al., 2003) that emphasized that the ready availability of powerful computers made this visualization tools very popular, and now it is very difficult to find novice students, expert students or even teachers in exercise that have never had any contact with these tools.

Searching the speech regularities we found as we mentioned before, several statements that relate the use of visualizations with the abstract nature of some identities and processes of the chemistry world. This concern with the understanding of the submicroscopic world appears in chemistry on the last decades of the past century. Several researchers attribute to the great difficulty that students have to cross the three levels of chemistry (macrochemistry, submicrochemistry and representational chemistry (Jonhstone, 1991) a major cause for the school unsuccessful in this science. These issues are discussed on the pre-service education in some of the pedagogical subjects, emerging in the speech of these pre-service teachers about the use of visualizations. Simultaneously the society expects that schools increase the success taxes and introduce new methodologies and new learning tools. These are some emergency conditions and the relations that incite the use of these visual tools, and the appearance of some none-speech practices.

The lower number of references between visualizations and its role in building knowledge is according Foucault' theory tied to the power and knowledge dynamics of our time. In one end this "event" shows the lack of education on this issue and on the other end the strong influence of the image in ours lives. As we can see in our results we found several statements relating visualization with the possibility to get students attention, to make classes more interesting, and in practice this was the most frequent purpose for the use of these tools. They don't show any especial understanding on how a visual representation is turned into knowledge and what are the mental processes that are involved in attaching meaning to a representation. They never mentioned the skills involved (Gilbert, 2007) in learning through these visual tools and the need to previously discuss with the students the codes and conventions associated to any visualization. They completely forgot that the intended purpose of the visualization and its relation to the referent is obvious for the teacher but sometimes is opaque to the novice pupils (Uttal & Doherty, 2008).

Describing this *Teacher*, according to Foucault's theory we found a person very conditioned by his pre-service course and by the changes on his society, especially in education. The way they use these tools doesn't reveal a reflexive practice, mostly they merely used these tools with no reflection on the impact of these tools on the apprenticeship. This concern with the need to become a reflexive teacher (Schön, 1992) is related with the possibility of him questioning, understanding and if necessary change his practice.

As a consequence, this reflects on the associated fields that appeared on their speech about the use of visualization on chemistry education. On their speech about these tools, as we referred before, we found a larger number of statements from the media field, especially related with the images impact, followed by a much lower number of statements from the educational field (pedagogic and didactic). This influence sometimes goes against to the initial use of representations on chemistry that was limited to communication and heuristics creation with the purpose to preview proprieties of the chemical objects, assigning to these tools ways of use very distinctive from that ones historically conceived in the middle of the XIX century. One of the great problems of using these tools without the necessary education stands on the fact that sometimes its usage is to give existence to objects that exists only in theory. Here we can see the need to teachers had a good comprehension to the concept of model in chemistry and the role of visualizations in chemistry education.

CONCLUSIONS

As conclusion we can say that these pre-service teachers aren't yet sensible to the impact of visualizations and they don't know how to use them in a fruitful way. It's clear on their answers that their use of visualization is more concerned with the external effect that visualizations cause, than to the internal effects of visualization itself. They never mentioned the supposed role of (external) visualizations on internal visualizations (mental models) and it seems that they aren't really aware of visualizations *power*. We could say that they use visualizations in a *naive* form. This was very clear when they used the animation; first they never mentioned its use as a representation and second they don't discuss with pupils the codes and conventions associated to every visualization. We also can say that there is an absence of some knowledge related to the skills need to make any visualization meaningful. First they don't show any particular understanding that it is necessary to improve *metavisual competence* (Gilbert, 2007) on the pupils, and second it seems that some of them begin to believe that visualizations could be a panacea for teaching some difficult scientific topics. Based on Michel Foucault (2000) we can refer that their choices on visualizations are strongly related to their conceptions about this issue and their conceptions about it are very week, demonstrating several gaps in their theoretical knowledge on models and in the role of visualization in chemistry education. The set of referents founded reveal a great influence of the media in their practices with these tools, which is a product of our historical context. As a final take away we can say through this sample that is necessary to improve the training of our future teachers and supply them with all the theoretical background necessary for them to apply this new tools with effectiveness in chemistry teaching.

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THE PRINCIPLES OF A SHORT TIME SEMINAR FOR DEVELOPING PROSPECTIVE GREEK PHYSICS TEACHERS' PCK

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Abstract: This study is a part of a wider effort to propose a curriculum and afterwards a time table for a short time didactical seminar which aims at prospective Science teachers and would affiliate issues of educational methodology and educational exploitation of technology. In this paper are described the educational actions that took place in order to develop the Pedagogical Content of Knowledge (PCK) of twelve students of the Physics department of the University of Athens through a thirty hours seminar. The seminar involved basic didactic concepts, educational methodology matters and ways to use educational technology. During the whole project students designed and they also developed educational material and at the end they conducted a normative lesson. The first findings show that they had formed only a very primitive PCK at themes that involve students' attitude, use of experiments as an educational tool, self-evaluation and decision rationalization. On the other hand they have developed their PCK at fields that don't include such delicate issues and that can be described through general norms, such as adopting an educational methodology, performing experiments, producing educational material and using technology. Further effort should me focus on prospective students' attitude towards technology implementation, students' learning and educational decision rationalization.

Keywords: PCK, prospective Greek teachers, seminar

INTRODUCTION-BACKGROUND

During the last years there has been a large conversation in Greece concerning the instructional quality and the educational results at the field of Science. Data interpretation of the PISA draw rather disappointing conclusions for the educational system as a whole and therefore education communities have been striving for increasing the quality of science and technology education. The Greek ministry of Education has recently proclaimed a wide program in order to change the curriculum in the primary and secondary education, mentioning the key role that teachers should play in this effort for the new era in education. It is clearly articulated that "teachers should be able to produce their own educational material that will reflect their own viewpoint and values about science syllabus". Moreover it is acknowledged the necessity to support teachers in their professional growth through a procedure that will affiliate contents that pertaining to educational methodology and educational technology, helping them to introduce the new acquisitions into their daily teaching.

Previous research efforts (Grigoriou & Kalkanis, 2009, Grigoriou et al, 2010, Grigoriou, Vithopoulou & Kalkanis, 2010) imply that Greek prospective Science teachers form only a very primitive PCK regarding the characteristics of some aspects, such as representations of subject matter, didactical strategies, the purposes and goals for teaching science, objectives and specific curricular programs and materials, students' attitude and requirements for learning specific science concepts self-evaluation and decision rationalization. On the other hand they have developed their knowledge at fields that don't include such delicate issues and that can be described through general norms, such as adopting an educational methodology, performing experiments, producing educational material and using technology.

In parallel, studies that have been conducted in Greece (Kariotoglou, 2002) show that the knowledge that Greek University students obtain from their studies is insufficient for their professional development and therefore is necessary to provide them an appropriate support in terms of pedagogical content. This is where PCK arises as one of the most crucial sub-domains (e.g. Grossman, 1990; Shulman, 1987) of teachers' professional knowledge. It should be mentioned that PCK is not a widely spread notion at the Greek Universities, as it hardly appears at the syllabus of the faculties' or departments' curriculum, apart from some prominent exceptions (such as University of Florina). Research pursues more or less the same direction as at the last Greek conference that took place at the mid of April of 2011, there were announced only 2 presentations regarding PCK.

A number of studies imply that educational support and appropriate opportunities to student teachers to design, implement and reflect on their educational action may contribute to broaden their PCK. Clermont, Krajcik, and Borko (1993) found that the PCK of preservice science teachers participating in a short, intensive workshop on specific teaching strategies developed towards that of expert teachers. Van Driel, De Jong and Verloop (2002) suggest that specific courses or workshops during teacher education have the potential to affect PCK, for instance, by extending preservice teachers' knowledge of students' preconceptions or their knowledge of specific representations of subject matter. On the other hand, according to Tytler (2005), training programs concentrated in a short single period are ineffective in promoting changes in teaching practice: training needs to last a long time and to be inserted into a real school context to embed new ideas into a teacher's personal experience. Alike, Adams and Krockover (1997) found that workshops can have a negative effect because they can stimulate preservice teachers to copy conventional instructional strategies, stressing procedures rather than student understanding.

PURPOSE-RATIONAL

Trying to contribute to the discussion according to whether PCK can be considered as a frame to design and implement seminars for prospective science teachers' professional development, this study describes the first steps of a wider effort to propose a curriculum and afterwards a time table for a short time didactical seminar in order to develop prospective Physics teachers' PCK, mentioning the experience that has been earned from this first attempt.

Many studies have been conducted in order to evaluate the effectiveness of this approach, targeting at researchers' contemplation not only at PCK theory but also at the means that PCK should be managed, promoting this thesis (Niess et al., 1999, Zembal – Saul et al., 1999, Watters et al., 2000, Van Driel et al., 2002, Aaltonen et al., 2003).

More precisely the research questions were:

1. How, and to what extent, the preservice physics teachers develop concrete aspects of PCK (knowledge of representations of subject matter and

understanding of specific learning difficulties and student conceptions) by participating in this short time seminar?
2. What are the participants' perceptions concerning the role of this seminar, in helping knowledge base development (actions, syllabus, tutor)?

At this point it should be clarified the framework within we use the term of PCK. After the initial intromission of the concept of PCK from Shulman in 1987 as "a special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" a lot of proposals have been made as didactical strategies that can materialize this basic concept. Although there has been no consensus on the PCK models and components, all scholars agree on Shulman's two key elements - that is, knowledge of representations of subject matter and understanding of specific learning difficulties and students' conceptions (Van Driel, Ver loop & de Vos, 1998).

An auxiliary verbalization for a science teacher are the answers to following questions: What shall I do with my students to help them understand this science concept? What materials are there to help me? What are my students likely to already know and what will be difficult for them? How shall I best evaluate what my students have learned?" Answers of these questions are the fundamentals of pedagogical content knowledge (Magnusson, S. Krajcik, J., & Borko, H., 1999).

RESEARCH FRAMEWORK-METHODS

The sample

The participants where 12 graduands of the Physics Department, who had attended a course of general didactic comprising principles of teaching, instructional strategies and use of technology in developing educational material. All the students were voluntary offered to participate and expressed their will to follow science teacher carrier. The tutor was the first author of the article.

Seminar Description

The seminar took place at the Science, Technology and Environment Laboratory of Athens Pedagogical Department. It lasted 15 sessions, 2 hours each, and we implemented it 5 times during the last 4 years. At each seminar participated 2 or 3 students. Viz, were tarined 3 dyads and 2 triads of students. That indicates the differentiation of the sample at each seminar.

Each session lasted 2 hours and it was divided in three terms: At the first term it took place an introduction from the tutor to the notion of PCK, analyzing each time different aspects. A presentation of normative educational material followed, affiliating the proposed concepts. At the second term tutor proposed a concrete science principal (such as electricity from the view of microcosm) and afterwards students were developing their lesson plans and the appropriate educational material for the specific subject matter issue. At the third term a procedure of reflection upon the developed material was taking place and at the last sessions a reflection upon the microteaching that students had already conducted.

Research tools

To capture a highly complex construct such as PCK in this qualitative research, a multi-method evaluation was followed. The tools were notes taken by the tutor in each session (during the second and third term), semi conducted interviews of the participants at the beginning and at the end of the seminar (audiotaped and then verbatim transcripted), the portfolio of students' developed material (lesson plans, worksheets, apparatuses), the videotaped microteaching that each student conducted.

The interviews at the beginning of the year focused on the students' educational background, expectations as a prospective science teacher and expectations from the seminar. Interviews with the students at the end of the seminar focused on experiences during the seminar, reflections on the assistance that was provided and proposals for future enhancement. Knowledge of representations of subject matter and understanding of specific learning difficulties and student conceptions were delineated through tutors' notes that were taken at the second term and through portfolios' analysis, identifying the educational reasoning at students' choices. Analogous processes to capture aspects of PCK were adopted by numerous scholars, such as "Lesson Preparation Method" by de Jong (2000), "CoRes and PaP-eR" by Mulhall, Berry and Loughran (2003), lesson preparation method followed by interview (Van der Valk & Broekman, 1999).

At the 13th approximately session of the seminar, student teachers conducted a microteaching. The subject topic was mutually agreed between the tutor and each of the student teacher. This lesson lasted 45min and it was conducted to freshmen students of the Pedagogical department. The reason for this choice was twofold: firstly convenience in terms of scheduling and handling and secondly because they present similarities with school students in terms of misconceptions and attitude towards science learning. Each microteaching was videotaped and used for reflection at the third term of the rest sessions.

The semi structured interviews were transcripted and analyzed by student's name and by category (e.g. expectations from the seminar, experiences during the seminar, reflections on the assistance that was provided, proposals for future enhancement). The analysis was mutually agreed between 2 independent judges.

The portfolio and tutor's notes was analyzed by student's name and by knowledge base category, generating subcategories for more specific tincture, such as didactic strategies, students' misconceptions, curricular material.

RESULTS-CONCLUSIONS

Knowledge of representations of subject matter

At the beginning of the seminar, all of them expressed negative attitudes toward the need to follow an educational methodology which is based to inquiry, because it requires more demanding preparation and thinking skills comparing to learning by lecture, with which they were familiar. However, when they understood more about the inquiry model of instruction and got involved to use it through their lesson plans they gradually developed more positive attitudes toward inquiry activities. The lesson plans' preparation enhanced the participants' understanding and reasoning about their choices and prompted complex thinking about physics teaching and learning. However, they face difficulties in tailoring activities and materials to the needs of their students and monitoring students' learning. At microteaching activity student teachers got involved with teaching in a conserved context. They had their first experience from the point of view of class management, time management and the complex nature of educational decision making. However, it was clearly revealed their weakness on content knowledge.

Understanding of specific learning difficulties and student conceptions

The participants came to the course with a varied mixture of existing knowledge and experiences concerning teaching and learning. Although the participants had attended a relative course all of them knew little about teaching, learning, and assessment. During the activities of their lesson preparation they emphasized the importance of being aware of students' misconceptions before teaching a topic although they didn't achieved a deeper level of dealing with them even at this preliminary stage of their lesson preparation. They became anxious in developing their lesson plans so they omitted anything that they regarded it was difficult for them to manage with, besides the recognition to the importance that may have that choice to the efficacy of their lesson. At microteaching activity student teachers faced questions that revealed misconceptions from the side of the students. Unfortunately student teachers they were not able to handle them choosing the convenient for them way to ignore and to change the discussion (Halim and Meerah, 2002).

By microteaching activity student teachers seemed to shift their awareness about teacher's role to a level that recognizes the importance for students learning to get engaged and facilitated into it rather than participating in an knowledge transmition procedure. Also, during the periods of lesson planning and micro-teaching, student teachers gained direct experience also as a learner and as a teacher. Reflections on that procedure led to the acquisition of a broaden knowledge encouraging the participants to develop and implement their topicspecific PCK, something that is also mentioned by Cochran et al., (1993).

Participants' perceptions concerning the role of this seminar, in helping knowledge base development (actions, syllabus, tutor)

Teachers felt personal interest because of their direct involvement in procedures of planning and implement a lesson which led them to a deeper understanding of the topic. Also this acted as a springboard to personal engagement to change traditional presentations by introducing the new acquisitions into their teaching.

IMPLICATIONS

Since the majority of the student teachers endorsed technology's worthiness in science education we suggest that technology should be studied further along the procedure of a seminar that it has the ambition to expand student teachers' PCK. A better established framework for the role of technology in teachers' education should be followed in the forward approach of the seminar, where TPCK could act (or not) supplementary.

Also, improvements should be made at the syllabus and the educational material provided towards technology implementation in science education and misconceptions manipulation as already mentioned before. Sudents teachers' inefficacy to handle students misconceptions could be the incorporation of more palpable proofs for the role that students' attitude and misconception play in their learning, through alterations to the seminars' syllabus so that it can comprises sessions with videotaped normative lessons and more chances for real condition teaching. This selection could provide useful service and in other aspects of PCK such as learning teaching strategies, setting and accomplishing specific educational goals as mentioned by Abell and Cennamo, (2003).

In parallel, an appropriate software development and implementation may contribute to facilitate student teachers to incorporate technology into their lessons, extricating more time for more fruitful actions towards the direction of students understanding.

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IDENTIFYING ELEMENTS OF PCK IN CHEMISTRY TEACHER EDUCATION

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Abstract: The explication of the pedagogical content knowledge (PCK) construct often remains subject-unspecific. Additionally the elements of PCK that can be acquired at university, where prospective teachers usually only have few opportunities to practice teaching, have not yet been clarified. This study aims to identify elements of chemistry-specific pedagogical content knowledge that are related to university teacher education programs. To elucidate the elements that are relevant in teacher education, expert-interviews with teacher trainers were conducted. By means of content analysis, the method of *analytical hierarchy*, based on Spencer, Ritchie & O'Connor (2003), is suitable for (1) developing categories, (2) labeling the interview data, and (3) abstracting from individual viewpoints to aggregate the statements of different experts to themes and concepts of chemistry-specific PCK for teacher education programs. The process of analysis is illustrated with an example that refers to the general facet: *knowledge of curricula and objectives*. Teacher trainees have to be familiar with the spiraling character and the chronology of chemistry issues. They should be sensitive to learning difficulties that may emerge from this and should have methods at their disposal for handling them.

Keywords: teacher education, chemistry-specific PCK, expert-interviews, content analysis, professionalization

Introduction

Since Shulman (1986, 1987) proposed a typology of teachers' professional knowledge, this approach has been pursued by numerous researchers. The core constructs content knowledge (CK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) have built the foundation for different studies. PCK attracts a particular amount of attention because it represents genuine teacher-specific knowledge and skills. Although more or less similar conceptualizations have been made, there are still no subject-specific (e.g. chemistry-specific) descriptions of PCK yet (Kind, 2009). Existing approaches often focus on pre-service (e.g. Van Driel, Beijaard & Verloop, 2001) and in-service teachers (e.g. Mulhall, Berry & Loughran, 2003). This is due to the common assumption, that teachers' competences develop through action and experience in class. In terms of university teacher education and its impact on the development of professional competence as well as the character and content of adequate professionalization, further research is still needed (Borko, 2004; Blömeke, Felbrich, Müller, Kaiser & Lehmann, 2008; Krauss et al., 2008).

With regard to the German teacher training program and its structure, it is necessary to draw a distinction between different levels of PCK. German teacher education consists of two phases. The first phase takes place at university. It emphasizes on acquiring theoretical knowledge in three areas: the subject-related scientific discipline, educational science and subject-related didactics. Student teachers have to pass a first state examination (or nowadays a bachelor and master exam) before they start their preparatory-service at school, which is the second phase. Pre-service teachers finish this supervised practicum in the field with a second state examination. The study aims to identify elements of chemistry-specific pedagogical content knowledge that are related to university teacher education programs.

We refer to a sociological approach in order to characterize the knowledge that is imparted at university. According to Radtke & Webers (1998), knowledge that is acquired at university has to be seen as the basis for professionalization. They distinguish between three types of knowledge: reflective knowledge, decisional knowledge, and routines. Decisional knowledge and routines are accumulated through teaching practice. At university, mainly reflective knowledge is acquired, for which teaching experience is not a necessary condition. By contrast, theoretical knowledge should not be communicated without drawing connections to practical examples. Teacher educators should link the reflection of theories to practical situations in order to prevent knowledge from idling (Eraut, 1994).

Radtke & Webers characterize this knowledge as a theoretical frame that should enable pre- and in-service teachers to reflect and justify their classroom-activities. For teachers these abilities are essential (Darling-Hammond, 2006). Eraut (1994, p. 60) describes the application of theories in order to "[…] interpret, explain or judge intentions, actions and experiences […]" with the term *theorize*. Non-professionals who are not able to *theorize* often analyze classroom activities according to their own experience as pupils. It is an essential goal of university teacher education to avoid that. The typology of knowledge of Radtke & Webers is not related to a specific content and is therefore applicable to every facet of (prospective) teacher knowledge: CK, PK, and PCK.

General descriptions of PCK in science can be found in literature. Adapted from Magnusson, Krajcik & Borko (1999) the construct contains:

1. Knowledge of science curricula and objectives,
2. Knowledge of students' misconceptions, difficulties and typical mistakes,
3. Knowledge of representations and analogies to facilitate students' learning of specific issues,
4. Knowledge of science-related strategies for instruction and
5. Knowledge of science-related diagnostics, assessment and evaluation.

Magnusson, Krajcik & Borko pointed out that PCK includes (1) the ability to align topics for vertical conjunction over the school years and with respect to national standards. Teachers (2) have to facilitate students' science learning based on their cognitive levels. Additionally, teachers should know about difficulties in learning science, reasons for those difficulties and possibilities for overcoming them. Successfully leading science instruction (3 & 4) implicates knowledge about structuring science-lessons and examples, which are suitable to foster students' understanding. This category demonstrates the importance of content knowledge especially well, and obviously also that the junction of PCK and CK remains blurry. At lastly, in order to adequately evaluate science learning, it is (5) necessary that teachers know about what to assess and how they should assess it.

What the different conceptualizations have in common is that they point out facets of (in-service) teacher knowledge without connection to a specific subject or the knowledge-level of teacher trainees. The study should contribute to bridging that gap.

Method

To identify elements of PCK in chemistry teacher education programs, a qualitative interview study will be conducted. The guided expert-interviews will follow developed manuals. Two different groups of experts will be brought in: teacher trainers at university (who are educational researchers as well) and teacher educators at school, who are supervisors of pre-service teachers. These two experts groups represent both institutions that are responsible for teacher education, so this is seen as a beneficial combination. The whole sample consists of sixteen interviewees, eight per group. The interviews take 60 to 90 minutes. In order to prepare them for content analysis, all interviews are audio-taped and transcribed. The qualitative analysis basically follows the “analytical hierarchy” that can be seen as a conceptual scaffolding according to Spencer, Ritchie & O’Connor (2003, Fig. 1). Starting from raw data, it includes several steps of data management, descriptive and explanatory accounts. The process of analysis is iterative. Moving up and down the stages is possible at any time.

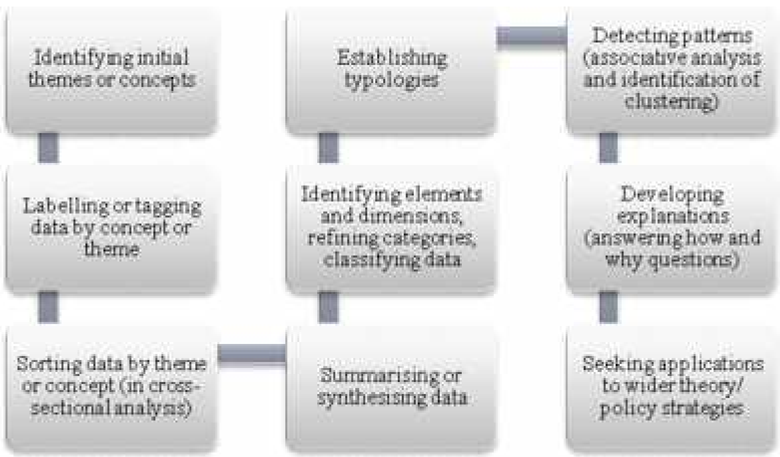

Figure 1. The Analytic Hierarchy, according to Spencer, Ritchie & O’Connor (2003). P. 212

Beyond analyzing the interviews case-by-case, this analytical hierarchy enables a cross-sectional analysis (analysis across different cases) at an early stage in order to aggregate the statements concerning a specific category of the different interviewees. For this reason the approach is attractive to this project. The first steps of data-management aim to develop a category system that provides the basis for further analysis. However, to acknowledge previous findings, the category system will not be based solely on the interview data. Theory-driven general facets of science PCK (compare Magnuson, Krajcik & Borko, 1999) constitute the main categories. Inductively developed subcategories represent chemistry-specific clarification. The constituent elements of university PCK for prospective chemistry teachers (which will be identified after the analysis of the interview data) will be presented to another group of teacher educators, namely educational researchers. They will be asked to rate the relevance and practicability of these elements to examine content validity and to ensure that only shared facets will be chosen for a following test-construction. The operationalization of approved facets will generate test-items in order to measure reflective PCK of prospective chemistry teachers.The analysis process has not yet been completed, but the results that will be published in the paper basically refer to the five steps shown in Figure 2.

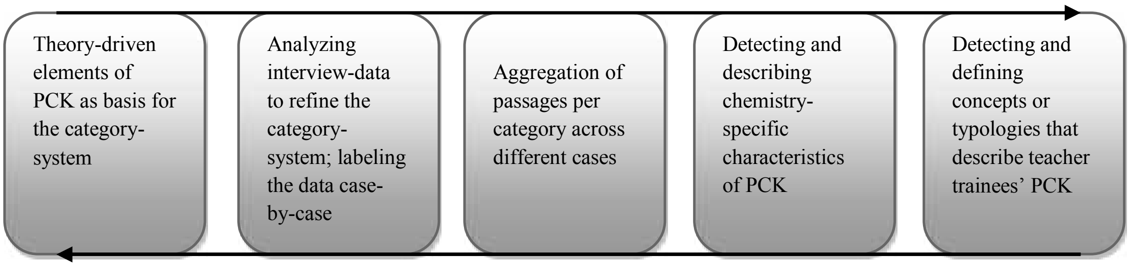

Figure 2. Iterative steps of interview-analysis

These five steps of analysis that are explained in the boxes describe the modification of the original process according to Spencer, Ritchie & O'Connor and its application for this project. The second box, for example, sums up steps one and two of the original work; the fourth box represents steps four to six of the analytical hierarchy. The chosen method helps call out the common facets of the PCK construct, which possess a more global quality. Applying them case-by-case in the analysis of the interview-data leads to an individual interpretation of chemistry-specific PCK. Interviewees were asked to use examples to explain their interpretation of PCK so the case-level is maximally personalized. In order to derive facets of chemistry-specific PCK-themes or -concepts for teacher education programs, it is necessary to abstract from particular cases. The results of the cross-sectional analysis can be placed between the global and the individual descriptions of the PCK construct. Figure 3 visualizes this process:

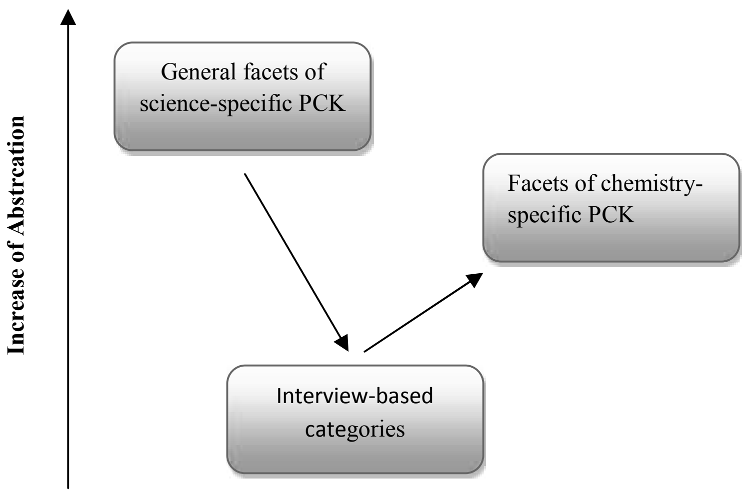

Figure 3. Process of developing a conceptualization of chemistry-specific PCK

Results

At this time, six interviews are being conducted, transcribed, and analyzed. To date, the sample consists of one interviewee who works as a teacher educator at university and five who are teacher educators of the second phase. All interviewees are male. Their work experience as teachers on average is eighteen years, and at least eleven years. Their work-experience as supervisors for pre-service teachers varies from three to nine years (on average 5.8 years). The interviewed supervisors of the second phase of teacher education train pre-service teachers at higher (N = 2, both gained a doctoral degree in chemistry education) and lower (N = 3) secondary schools. The following table provides an overview of some selected results. The columns refer to the first three boxes of Figure 2.

Table 1. Selected results after 6 expert-interviews.

Theory-driven facets of science-specific PCK (adapted from Magnusson, Krajcik & Borko, 1999)	Categories for labeling the interview-data	Chemistry-specific characteristics of PCK
Knowledge of the curriculum and objectives	- Aims of chemistry education: - content-related goals of chemistry education, section of students' competence	Knowledge of the National Educational Standards for chemistry and their implementation during instruction; Knowledge of the spiral development of chemistry issues
Knowledge of students' misconceptions difficulties and typical mistakes	- Examples for chemistry-specific misconceptions - Examples for chemistry-specific learning difficulties	Knowledge of ways to facilitate the understanding of the relationship of macroscopic and submicroscopic issues; Knowledge of difficulties and potential regarding models during chemistry instruction
Knowledge of representations and analogies to facilitate students' learning of specific issues	- Reasons for learning-difficulties in chemistry: spiral curriculum terminology	Knowledge of determining factors for chemistry instruction: criterions for selecting representative chemical issues, methods, and experiments
Knowledge of subject-related diagnostics, assessment and evaluation	- Kinds of measuring students' chemistry competence - Assessing students' experimental skills	Knowledge of possibilities for chemistry-specific assessment
Knowledge of subject-related strategies for instruction	- Suitable methods - Suitable experiments - Practical skills - Examples for successful teacher-acting	Knowledge of ways to implement scientific reasoning and criteria for selecting adequate experiments for instruction: e.g. context / relevance of chemistry issues, institutional possibilities and limitations (adherence of security standards, funding, course-size)

The following explanations refer to the first line of the table in order to exemplify the whole process of data-analysis.

To detect reflective pedagogical content knowledge for chemistry teacher education, the statements of the interviewees were summarized and aggregated into more common concepts. After analyzing the first interviews and abstracting from the individual perspective, results for the general facet knowledge of the curriculum and objectives can be outlined:

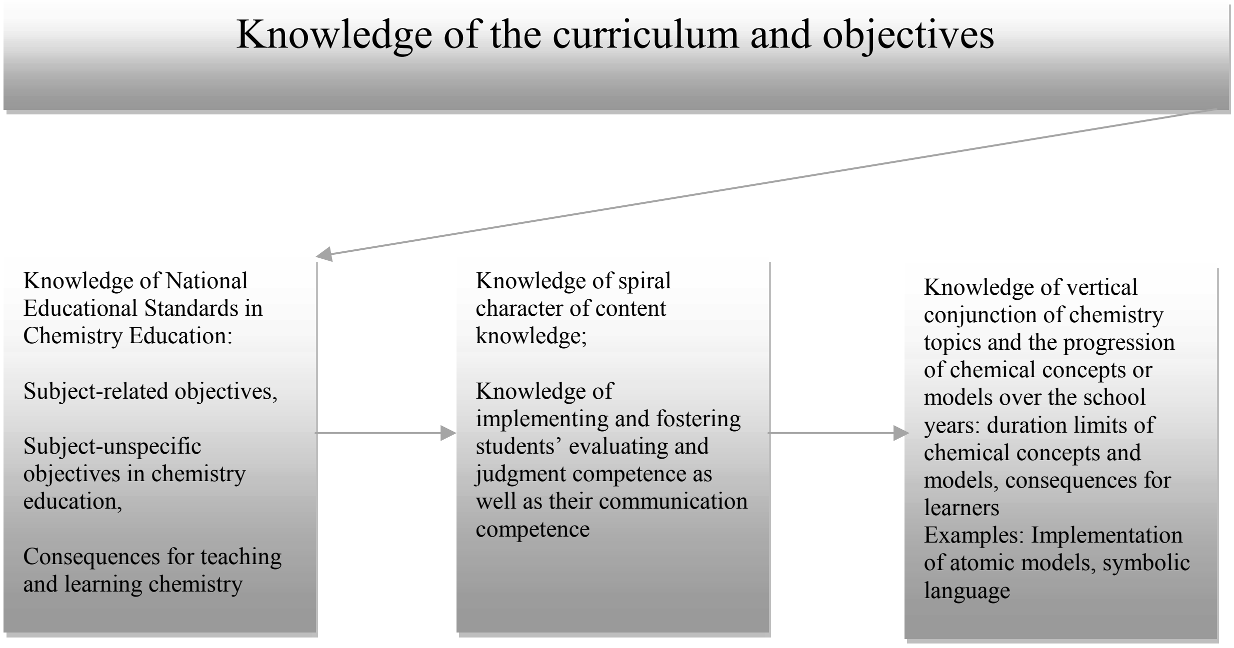

Figure 4. Process of curriculum-development

One facet of prospective chemistry teachers' reflective knowledge is to understand the spiral character of content knowledge and its consequences for structuring lessons. According to the interviewees, prospective chemistry teachers have to be familiar with national curricula in chemistry education, and they have to know about chemistry-specific objectives. In order to distinguish this knowledge from CK, how chemistry issues are introduced and developed during chemistry instruction needs to be stressed. This is important, even if just for the students' perception of the subject. Prospective teachers should be sensitive to and prepared for the reality that students will always need knowledge from previous years, a factor that is less significant in biology, for example. Prospective teachers should not underestimate how this factor could influence students' attitudes towards chemistry. Another aspect that could affect students' interest in learning chemistry concerns the duration limits of chemistry concepts. Knowledge that is imparted at school is temporary, which generates dissatisfaction. Knowing strategies to handle this have to be part of reflective chemistry PCK.

Discussion and options for further research

Because there are still interviews remaining, this paper has focused on the method and the process of data analysis. Nevertheless, first results of six interviews show that it is indeed possible to deduce facets of prospective chemistry teachers' knowledge that should be acquired at university. The chosen method is appropriate for deriving common facets from individual statements. After conducting and analyzing the whole sample, the study will conclude by developing a curriculum for chemistry teacher education programs.

Matching both expert groups of teacher educators creates a valuable, comprehensive view of chemistry-specific PCK -elements and –examples. This clarification of the construct will be the foundation for developing a quantitative PCK test for prospective chemistry teachers. This developed test instrument will be piloted within the presented project. Further projects will then have recourse to the test in order to measure student teachers' outcomes. The evaluation of the impact of teacher education in Germany is one necessary step towards detecting avenues for bigger-picture improvements.

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PRE-SERVICE SCIENCE TEACHERS PERCEPTIONS RELATED TO EPISTEMOLOGICAL WORLD VIEW AND SCIENCE TEACHING EFFICACY BELIEF

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Abstract: The purposes of this study were to describe pre-service science teachers' (PSTs) epistemological word view and science teaching efficacy beliefs and to explore how PSTs' epistemological word view can be predicted from linear combination of science teaching efficacy, taking course relating nature of science (NOS), and the number of teaching method course PSTs took. Epistemological World View (EpWV) Instrument and Science Teaching Efficacy Belief Instrument including personal science teaching efficacy (PSTE), and science teaching outcome expectancy (STOE) dimensions was administered to 68 PSTs participated from two different public universities. Findings revealed that the PSTs' scores about EpWV, PSTE, and STOE were favorable level. The result also indicated that PSTs' personal science teaching efficacy, taking NOS course and the number of teaching method course was significantly contribute to the PSTs' epistemological word view. This model explained the 16,6 percent of variance of the integration scores. Both personal science teaching efficacy and PSTs' taking NOS course had almost equal and positive contribution to explaining the PSTs' epistemological word view. Furthermore number of course dealing with teaching method made the strongest unique positive contribution to explaining the PSTs' epistemological word view. Our research suggested that it should be given importance to the courses related to teaching methods and NOS while application of current teacher training programs in the universities. This approach may improve PSTs science teaching efficacy belief and their epistemological word views, which are the two important factors for students learning and effective teachers' classroom practices.

Keywords: Pre-service science teachers, epistemological word view, science teaching efficacy beliefs, teaching method course, nature of science course

BACKGROUND, FRAMEWORK, AND PURPOSE

There are many efforts to improve teacher education and to overcome some problems in the teacher education (Karagozoglu, 1991). Eight year compulsory education increased universities' pre-service teachers' capacity to educate more teachers and the awareness about the necessity of new strategies in teacher training programs. Therefore, teacher training programs has been changed from different aspects. For example, pedagogical courses were added and the number of methods courses was increased. It was also given importance to teaching skills for effective instruction in method courses (Tekkaya, Cakiroglu, & Ozkan, 2004). In the literature Schraw and Olafson (2002) and Howard, McGee, Schwartz, and

Purcell (2000) emphasized the relationship between teaching practices and epistemological word views. Epistemological world views refer to "teachers' collective beliefs about the nature and acquisition of knowledge" (Schraw & Olafson, 2002, p. 102). Literature reveals three types of epistemological word views namely realist, contextualist, and relativist. Teachers with realist world view transmit fixed body of knowledge to students as passive recipient. Teachers with contextualist word views give more importance to the process of the students' construction of knowledge as facilitator. Teachers with relativist world views create an environment where students can learn to think independently and support the idea about what they know and believe shouldn't really influence their students. In the literature researchers agreed that students and teachers had different epistemological word views that lead to differences in teachers' instruction and students' learning (Schraw, Crippen & Hartley, 2006; Schraw & Olafson, 2006). Teaching efficacy belief is another important factor that influence teachers' effectiveness (Enochs & Riggs, 1990) and student learning and related factors (Woolfolk, Rosoff & Hoy, 1990). Teaching efficacy beliefs include both personal science teaching efficacy referring to perform effective science teaching behaviors and science teaching outcome expectancy referring to behaviors to produce desirable outcomes (Enochs & Riggs, 1990).

The purposes of this study were: (1) to describe pre-service science teachers' (PSTs) epistemological word view and science teaching efficacy beliefs and (2) to explore how PSTs' epistemological word view can be predicted from linear combination of science teaching efficacy, taking course relating nature of science (NOS), and the number of teaching method course PSTs took.

RATIONALE

The new vision of Turkish science and technology program and reform on teacher education program increased the importance of teacher role and beliefs in classroom. Although in all of the universities there is nationwide teacher education program curriculum proposed by Council of Higher Education, design and application of these courses in universities might be different. These differences also might influence pre-service teachers' epistemological word views. Moreover, in the literature there is limited number of studies about pre-service and in-service teachers' epistemological word views (Schraw & Olafson, 2002; Yilmaz-Tuzun & Topcu, 2007). Yilmaz-Tuzun & Topcu (2007) found that teachers' epistemological belief, epistemological world views, and self-efficacy beliefs were related to each other.

METHODS

Sample: To this study 68 PSTs participated from two different public universities. Approximately 84% of the all PSTs in these universities completed all of the survey questions.

Epistemological World View Instrument developed by Schraw and Olafson (2002). This instrument was translated and adapted into Turkish by Yilmaz-Tuzun and Topcu (2007). This instrument included three 5 likert type items assessing three different epistemological word views and these items referring realist, contextualist, and relativist word views.

Science Teaching Efficacy Belief Instrument (STEBI-B) developed by Enochs and Riggs (1990) was used to determine PSTs' self-efficacy beliefs about teaching science. STEBI-B including 23 items 5 likert type instrument consists of two sub-dimensions namely personal science teaching efficacy (PSTE) (13 items), and science teaching outcome expectancy (STOE) (10 items). Reliabilities of these subscales were reported .89 and .76 respectively by Enochs and Riggs (1990). STEBI-B was translated and adapted into Turkish by Tekkaya, Cakiroglu, and Ozkan (2004) and alpha coefficients of these subdimensions were reported .84 and .76 respectively in their study.

RESULTS

Descriptive Statistic: For our first question descriptive statistics on PSTs' perceptions about epistemological word view (EpWV) and science teaching efficacy beliefs were calculated (Table 1). The PSTs' scores about EpWV (M=3.63, SD=.49), PSTE (M=3.99, SD=.34), and STOE (M=3.60, SD=.40) were favorable level. Results were shown in Table 1. In epistemological word view, each scene (item) assesses the different epistemological word view, therefore the percentage of most selected answer for each scene were also calculated to provide information about PSTs' epistemological word view. While 41 PSTs (% 60,3) marked 'I do not agree' option about the scene related to realist word view, 44 PSTs (%64,7) marked 'I certainly agree' option about the scene related to relativist word view. Furthermore, 49 PSTs agreed with the scene related to contextualist word view.

Table 1 *Descriptive Statistic Results*

	M	SD
EpWV	3.63	.49
PSTE	3.99	.34
STOE	3.60	.40

Multiple Regression Analysis: A standard multiple regression analysis was conducted to evaluate how well the PSTs' epistemological word view predict their science teaching efficacy beliefs, whether PSTs' taking NOS course and the number of course regarding teaching method. The result indicated that PSTs' personal science teaching efficacy, taking NOS course and the number of teaching method course was significantly contribute to the PSTs' epistemological word view (Adjusted R^2 =.16, F (3, 67) = 5.449, p= .002). Results were presented in Table 2.

Table 2 *Multiple Regression Results*

	β Weight	Adjusted R^2	F	p
EpWV				
MCourse	.52	.166	5.449	.002
PSTE	.33			
NOS course	.31			

This model explained the 16,6 percent of variance of the integration scores. To examine the way that each independent variable contributed to the model, we looked at the beta (β) values. Both personal science teaching efficacy belief and PSTs' taking NOS course had almost equal and positive contribution to explaining the PSTs' epistemological word view with the beta values β= .33 and β= .31 respectively. Furthermore number of course dealing with teaching method made the strongest unique positive contribution to explaining the PSTs' epistemological word view with the β= .52. STOE did not significantly contribute to the explanation of the PSTs' epistemological word view.

CONCLUSIONS AND IMPLICATIONS

This study revealed that the PSTs' epistemological word views showed difference from realist to relativist. Percentages of the agreement on the contextualist and relativist epistemological word views are higher than that of realist epistemological word view. Since PSTs' views influence student learning in different ways, it is necessary to improve their views and find the factor that related to these views. Also pre-service science teacher had high level of PSTE and also respectable level of STOE but not as high as PSTE. These results might be related to giving more emphasis on teaching methodology and teaching practice in teacher education programmes. In this study, it can be concluded that the more courses related to teaching methods the PST take, the more desirable level of epistemological word views they have. Furthermore, in this study it was found that taking courses which emphasized NOS were likely to make PSTs to believe relativist world view where they support the effectiveness of student-centered teaching approaches. Moreover, the PSTs personal science teaching efficacy positively and highly related to their epistemological word views. These findings might be explained that by the help of these courses, the PSTs may develop beliefs in that they can teach science effectively or find better ways to teach science (high PSTE) and avoid being transmitters of fixed body of knowledge. In other words they prefer to be facilitators for students to construct their own knowledge for themselves. Our research suggested that it should be given importance to the courses related to teaching methods and NOS while application of current teacher training programs in the universities. This approach may improve PSTs science teaching efficacy belief and their epistemological word views, which are the two important factors for students learning and effective teachers' classroom practices.

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CURRICULUM GUIDELINES AND INSTITUTIONAL ASSESSMENT IN PHYSICS TEACHER EDUCATION: UNDERLYING CONCEPTS

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Abstract: The Physics teachers training has been subject of debates in various fields of research in Education. Among several issues, the articulation between specialized knowledge in Physics and pedagogical knowledge is defended. In Brazil the Ministry of Education established curriculum guidelines for higher education and mechanisms for institutional evaluation composed of different instruments, among them the ENADE (National Exam of Students Performance). Considering that the practices at the University, as well as the practices employed in teacher education in some way are not just influenced by these evaluations, but they also somehow influence on them, we conducted an analysis of the ENADE (2005 and 2008 editions) of the specific degree in physics teaching, in light of the teaching competences highlighted by the Curriculum Guidelines for teachers career. We try to understand the teacher training conceptions in it, as they seek to close the gap between the knowledge of the science to be taught (Physics) and the pedagogical knowledge. The analysis of ENADE showed a predominance of test questions that emphasize the physical content in detriment of educational content and very low occurrence of questions linking the two contents. Thus, although the research in Physics teachers training and the curriculum guidelines suggested interaction between different knowledge and competences, the actual examination to evaluate the performance of pre-service Physics teachers deal with it in a disjointed way.

Keywords: teachers education, Physics teachers, teachers competences, assessment, ENADE.

INTRODUCTION

The debates preceding the adoption of the current Law of Directives and Bases of National Education (LDB) (Law No. 9394, 1996) in Brazil involved a number of discussions closely related to the teachers training. Following approval of LDB, other laws and norms have come to light, such as curriculum guidelines for elementary and high school, and curriculum guidelines for the various careers of Higher Education, among them, the teacher training.

For the Physics teachers training, two national curriculum guidelines were established: Curriculum Guidelines for Undergraduate Courses in Physics (Parecer CNE/CES 1.304/2001) and the Curriculum Guidelines for Undergraduate Courses in Teachers Training (Resolução CNE/CP 1/2002), abbreviated here for CG-Ph and CG-TT, respectively. The establishment of these guidelines led many universities to reshape their curricula, adapting to the new legislation and seeking to incorporate the recent knowledge produced in the in teachers' education researches.

This context is summarized in Figure 1. The gray frames represent the fields in which the research was performed, underlined and bold fonts indicate the Curriculum Guideline assumed as reference to the analysis.

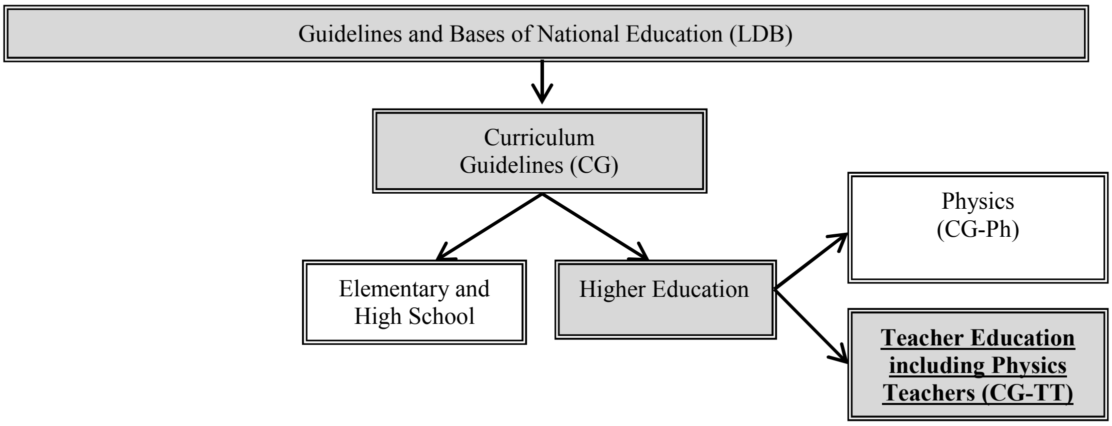

Figure 1: The context of the Curriculum Guidelines for Undergraduate Courses in Teachers Training.

Aiming to complete the cycle of designing and implementing the legislation, besides curriculum guidelines, the Brazilian Education and Culture Ministry established institutional mechanisms for evaluation, organized in the National System of Higher Education Evaluation (SINAES). This system consists of three types of evaluations, among them a student performance assessment, carried out from ENADE (National Exam of Students Performance).

Thus, since this formation is regulated by the guidelines and is subjected to an institutional evaluation through SINAES, it was made an analysis of the ENADE in light of the teachers competences highlighted in CG-TT, in order to understand how the different knowledge and competences are/are not articulated in the Examination which the future physics teachers are subjected. It is necessary to reflect on what it intends to evaluate and what parameters are set for this evaluation. Let us focus the analysis on the factors which indicate needs or opportunities to link physics contents and pedagogical knowledge in teacher education.

TEACHING COMPETENCES

The physics teachers training has been subject of debates in various fields of research in Education. Among several issues, the necessary relationship between the knowledge of the science to be taught (Physics, in this case) and the pedagogical knowledge is a widely discussed and defended issue.

Zimmermann and Bertani (2003), for example, pointed out that researches in this area have pointed the disconnection between the academic content and future teachers expected practices, besides the separation of the specific physics sciences and pedagogical subjects. To Carvalho (2001) the importance of knowing the content to be taught is a consensus among teachers and teacher educators, but it is necessary that the conceptual and methodological knowledge of specific areas are dealt with in an integrated way (CARVALHO, 2001, p. 118).

Related to these aspects, the CG-TT, in its 5th Article, mentions that the school contents must be emphasized in teacher's training in coordination with specific didactics, in our case, the didactics of Physics. In its 6th Article, it describes the various classes of competences that a degree course should seek to develop a student / future teacher:

> *I - competences for the inspiring commitment to the values of democratic society;*
>
> *II - competences related to understanding the social role of the school;*
>
> *III - **competences related to mastering of school contents (our highlight)** to be socialized, and their meanings in different contexts and its interdisciplinary articulation;*
>
> *IV - **competences related to mastering pedagogical knowledge (our highlight)**;*
>
> *V - The competences related to knowledge of research processes that enable the improvement of pedagogical practice;*
>
> *VI - competences for the management of their own professional development. (Resolução CNE/CP 1/2002, p. 3)*

For our specific case, the "school contents" mentioned in the CG-TT refers to the Physics contents.

These competences indicate that it is important that teachers have this plural knowledge, required for their classroom practices. This way, these competences must be indicative for working in undergraduation, as guidelines for the curriculum, as well as in designing evaluations for this undergraduation, once they were legally established by the CG-TT. We emphasize the competences III and IV, which form the basis for the analysis that we carried out on the ENADE.

METHODS

We performed an analysis of some questions that composed the ENADE in 2005 and 2008 editions, applied for undergraduate courses in Physics. The examination is applied to freshmen and seniors, and in a period of four years, it is applied again for the same undergraduation. Every year, the Enade consists of 40 questions::

- 10 Questions: General Knowledge (for students from all courses that are taking part of the ENADE in that year, including both Physics and Physics Teacher Degrees);
- 20 Questions: Specific Contents (Physics) addressed to all Physics students, regardless of the emphasis of the course (Physics or Physics Teacher Degrees);
- 10 Questions: Specific Component:
    - 10 directed only to students in Physics Teacher Degree and
    - **10 directed only to students in Physics Degree.**

We analysed these 10 test questions specifically addressed to Physics Teacher Degree, using as reference the competences mentioned in the CG-TT (National Curriculum Guidelines for Undergraduate Courses for Teachers Training), especially competences III (mastering of scholar contents to be socialized and their meanings in different contexts and its interdisciplinary articulation) and IV (mastering pedagogical knowledge). Once we choosed to analyse two Exams (2005 and 2008 editions), it was analysed 20 questions in total.

Figure 2 resumes this context. The gray frames represent the fields in which the research was performed, and underlined and bold fonts indicate the type of analysed questions.

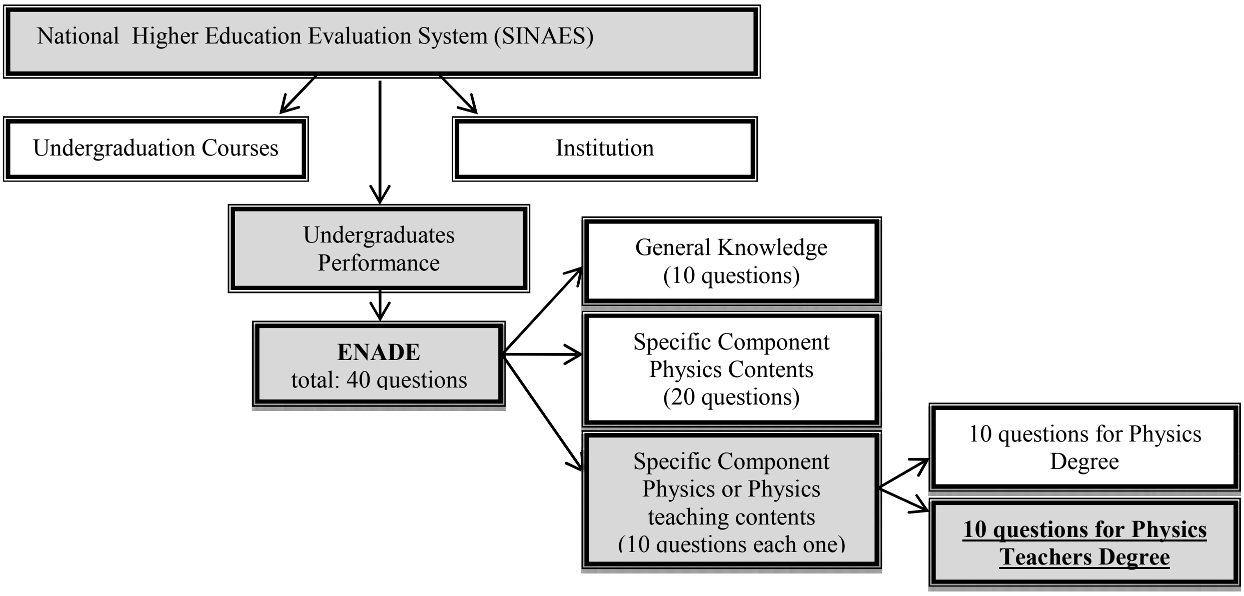

Figure 2: The context of ENADE. Underlined and bold fonts indicate the type of analysed questions

We analysed how, and in how many test questions are made references to a learning physics situation, what is its nature and what competences, those described in the curriculum guidelines, are evaluated in each question. In other words, we searched the presence or evidence of the appreciation of the relationship between science contents knowledge (Physics) and pedagogical knowledge, understanding that this relationship is crucial to establishing the desired relation between theory and practice.

THE ANALYSIS OF ENADE

The analysis shows that the exams consisted of three groups of test questions: Group I - Questions focused on the contents of Physics, Group II - Questions focused on the contents of education (Physics teaching) and Group III - Questions in which Physics and education knowledge are articulated.

It is provided one example of a test question in each group, as follow:

Group I - Focus on the contents of physics science: Test questions whose focus is centered on the assessment of competence "**mastering of school contents**..." i.e. the Physics contents.

> *"The development of educational action from the construction of political-pedagogical projects has become compulsory to schools. In this context, the Physics must be involved, taking the advantage of teaching moments to work their contents. In a hypothetical school, performing a play is one of these moments. Physics teachers decided to work with the Theme 4 of the PCN+: Sound, Image and*

Information. The Physics Project will work with the stage lighting, not forgetting the set designer guidelines. The characteristics of the theatre are: the walls of the stage, when illuminated with mixed green and red light, turn yellow. The floor, when illuminated with mixed green and blue light, is cyan. The colours of the walls of the stage and floor, respectively, are:

A) yellow and blue.

B) yellow and yellow.

C) green and magenta.

D) blue and white.

E) white and white."

In this question it is described an innovative pedagogical situation, to be developed in an interdisciplinary context at school. It provides some details about the activity development, stressing the importance of this kind of teaching methodology in a specific content. However, the question itself is not related to the teaching methodology, it is centred in the Physics content. If the question was composed just using the final part (after "*The characteristics of the theatre are…*"), suppressing all the description of the teaching methodology, it would be perfectly possible to answer the question, just knowing the mixing colours and light of different waves length theories. This way, the question is not addressed to assess the future teacher competence in conceiving or perform this kind of innovative pedagogical activity. So, the main goal of this question is to assess the "*competence related to mastering the school contents...*".

Group II - Focus on the contents of education: Test questions focused on assessing the competence of "mastering pedagogical knowledge". These are questions that relate to specific strategies of physics teaching but do not provide inputs related to the physical content.

"For many years, the exclusive application of long lists of exercises was considered a good strategy to teach physics in high school. Today, it is known that the long lists have limited efficiency.

a) Address the main limitations of this strategy.

b) Propose additional activities to this strategy.

c) Justify the activities mentioned above."

In this question it is assessed the future teacher competences in analysing a specific teaching strategy knowing its limitations, besides their skills to propose complementary strategies. This way, it is addressed to assess the "*competences related to mastering pedagogical knowledge*". Nothing about the Physics contents is assessed in this question.

Group III - Articulation Physics science and education: These are questions that measured the two competences, through the exploration of didactic situations in context in the Physics teaching.

"Recognizing that democratic systems are vulnerable without scientific culture, a physics teacher agreed with the concerns expressed in National Curriculum Parameters (PCN) on the citizen education and the suggestions of curricular changes to be adopted in schools. From this perspective, taking into account the contextual aspects in daily life and History of Science and the epistemological and methodological aspects of Physics Education, describe an activity to be held in a Teaching Unit in the Theme "Universe, Earth and Life", for each skill below.

a) Enhance an "understanding of the current hypotheses, models and forms of research on the origin and evolution of the Universe."

b) Identify ways in which explanatory models of the universe influenced the culture and human life throughout the history of humanity and vice versa."

This question is organized in two items. To obtain the highest grade in this question, the future teacher needs to know not only one specific Physics content (Theories of Universe, related to Earth and Life), but it is necessary to know how to organize a didactic activity, contextualized in the historical, epistemological and cultural aspects that involves this Physics content. So, it is focused on assessing the future teacher in both competences: "mastering of school contents..." and "mastering pedagogical knowledge...".

This kind of analysis was performed to all ten questions for Physics Teachers Degree, for both 2005 and 2008 Exams.

RESULTS

The overall results are summarized in the Table 1:

Year (edition)	**Number of analysed test questions (total)**	**Evaluated Competences**		
		(Group I) Mastering Physics Contents	(Group II) Mastering Pedagogical Contents	(Group III) Both Competences
2005	10	6	3	1
2008	10	4	4	2

Table 1: Synthesis of test questions and competences analysed in the ENADE, 2005 and 2008 editions.

It is observed that mainly in the 2005 Exam it was given prominence to test questions related to mastering the physical content by the physics teacher in training. Secondarily were the test questions related to strategies and methodologies of teaching that could be used in situations of physics teaching. In the 2008 examination, the number of questions designed to assess the physical content is equal to the number of questions designed to assess the field of educational content. However, it is possible to question this figure, once the domain of physical content has been evaluated in those 20 Component Specific test questions, answered by all undergraduates of Physics, independent of professional emphasis (BA or BS). The results also stress issues that test questions of Group III, which we consider important for an integration of theory and practice, were rarely present in the exam, and the greater emphasis was on test questions dealing with physical or educational content in an isolated way.

We are not considering that the questions which compose the exam are inadequate, but that the exam, as a whole, bringing matters only in certain content over others, shows a certain conception of teacher training, dissonant to that recommended in research on physics teachers education and the CG-TT, in respect to relations between the physics content and pedagogical knowledge.

CONCLUSIONS

From the analysis carried out with the ENADE tests it was possible to see that there is a tendency of teacher education in which the knowledge were presented disjointed from each other. We realize that the test questions in general are focused on competences related to the domain of content of physics or competences related to the domain of pedagogical knowledge, in isolation.

Noting the difficulties present in the physics teachers training described in the researches, and curriculum guidelines to teachers education, we observe that it is necessary to reach an issue that isn't yet present in the physics teacher education, related to their own legislation and institutional evaluation.

Facing these results, one must still question the concept of teacher evaluation model present in these analysed documents and the implications in the setting of teaching in higher education and the possibilities to bring changes in the current teacher training model.

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WORKING WITH THE MICROSCOPE AS A PROBLEM SOLVING PROCESS

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Abstract: A commonly used model of scientific method competence, e.g., experimentation, includes the following dimensions: lab work, scientific inquiry and nature of science. Working with the microscope has to be seen not only as a technical part of lab work. It is another demanding skill of acquiring knowledge in Biology. A better understanding of the influencing factors is required to promote the appropriate use of microscopes in schools. We assume that microscopy as a special problem solving process increases the motivation. We have developed and evaluated teaching units for pre-service student teachers. A short questionnaire for the measurement of intrinsic motivation (Ryan & Deci 2000) was employed. In addition, all participants were asked to assess their interest in various areas of biology and their own skills in microscopy. The study consist of two sub studies in 2010 (n=243) in courses of human biology. The students often could decide themselves, which problem solving method they prefer. During the treatment with a higher degree of self-determination, there was a positive development of interestedness. The values of the respective interest and self-determination are highly correlated. Our investigations within the groups of students give first hints on how the skills to use the microscope for problem solving can be promoted. The positive factors must be considered in the development and testing of training modules for schools.

Keywords: scientific method competence, microscopy, motivation

THEORETICAL BACKGROUND

The skills of gaining knowledge are of central importance for science education.
A commonly used model of scientific method competence includes the following three dimensions: *lab work* (practical work), *scientific inquiry*, *nature of science* (Bayrhuber et al. 2007, Kremer, Urhahne & Mayer 2007). The Scientific Discovery as Dual Research model by Klahr (2000) also focuses on three dimensions of experimentation (*analysing data*, *planning experiments*, *recognizing hypotheses*). Working with the microscope has not only to be seen as a technical part of lab work but also as another demanding skill of gaining knowledge in Biology. Many authors point to the possibilities of microscopy for research-based learning. But few studies exist so far on the frequency or the level of the use of microscopes in the classroom (e. g. Vogt et al. 1999) and the effects of interventions on motivation and skills.

RATIONALE

The intention of the study is to develop a strategy for the development of student’s ability to use microscopes as instruments for problem solving. Student Teachers often take the view expressed; scientific knowledge is best learned by heart and tested in exams. To promote the appropriate use of microscopes in schools a better understanding of influencing factors is required. How can teachers be supported in order to work better and more often with the microscope? The interests of future teachers to do research with the microscope should be strengthened. We suspect that microscopy as a special problem-solving process increases motivation.

Our model of development of competencies in terms of working with the microscope contains the following steps:
level 1- basic practical knowledge about the use of the microscope;
level 2 – the conviction of the usefulness of the application of the microscope in different situations;
level 3 - the use of the microscope specifically to clarify scientific phenomena (*scientific reasoning*);
level 4 - an appropriate use of the microscope in Biology is associated with a clear understanding of the cell concept of living beings (*epistemological views*).

METHODS

We developed and evaluated units for pre-service student teachers focused on the fostering of students' competencies in discovery with microscopes.

A short questionnaire for the measurement of intrinsic motivation was applied. This short scale of intrinsic motivation is a version of the "Intrinsic Motivation Inventory". It represents the factors interest/enjoyment, perceived competence, perceived choice and pressure/tension (5 –point Likert Scale, 5 agree completely, 1 disagree).

The main study consisted of *two sub-studies* which were conducted in *summer* and in *winter terms 2010* in 3 respectively 5 Biology courses of Human Biology for pre-service student teachers. *All measurements were repeated in summer 2011 (n=65) with the following course, but with another instructor.*

In the *pilot sub-study*, student teachers were introduced to microscopy over one semester in two different treatments (n=69). The two versions differed in the degree of self-determination. The internal consistencies for the short inventory of interest range from Cronbachs' alpha = .704 to .867 (10 items).
In the *second sub-study* in winter term 2010 (n=174, age median 21), the instructions for setting the learning pathway were reduced in all five groups. The units were modified in some parameters, e. g. in the frequency of use of the microscope. Courses 1 and 2 were run by the same person *(Results: Figure 1),* courses 3 to 5 by another person. On each day of the course all students were asked to complete a short questionnaire on intrinsic motivation and estimate how long they worked with the microscope *(Results: Figure 1, Table 3).* The internal consistencies for the short inventory of interest range from Cronbachs' alpha = .727 to .861 (9 items).

In a preliminary test, all students were asked to assess their own skills in microscopy, and they were asked to assess their interest in various areas of Biology (Table 2), and their knowledge of some technical terms (*Erythrocyte, Alveolar, Pituitary glands*, white matter, and so on).

RESULTS

How often did you … when you were at school as a pupil	Mean n=174 winter 2010/11	SD winter 2010/11	Mean n=69 summer 2010	SD summer 2010	Mean n=65 summer 2011	SD summer 2011
keep pets	1.69	0.92	2.36	1.37	1.58	0.73
use the microscope	2.33	0.71	2.48	0.87	2.375	0.63
dissect animals	1.29	0.54	1.41	0.63	1.37	0.49
use methods of Molecular Biology	1.54	0.75	1.32	0.63	1.39	0.79
visit a laboratory	1.81	0.79	1.77	0.75	1.76	0.73
plan your own experiments	2.17	0.89	2.29	1.09	2.14	0.96
prepare food	1.75	0.94	2.30	1.49	1.82	0.95

Table 1: Practical work at school, students assessments
Likert scale: 1= never / 5 = very often (summer 2010) and 1= never / 4 = very often (winter 2010, summer 2011)

Sum cumulated	summer 2010 pre-test n= 69				summer 2010 post-test n = 44				winter 2010/11 pre-test n = 174				winter 2010/11 post-test n = 118				summer 2011 pre-test n = 65				summer 2011 post-test n = 51			
Interests: 1very interested in… 4 not interested in …	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
plants	7	58	68	69	6	29	42	44	14	129	173	174	14	77	116	118	6	47	65	65	2	25	51	51
animals	28	67	69	69	21	44	44	44	96	170	174	174	68	115	118	118	34	62	65	65	17	49	51	51
Human Biology	26	63	69	69	23	41	44	44	73	172	174	174	43	98	116	118	28	59	64	64	22	47	51	51
Molecular Biol.	6	25	62	69	6	21	39	44	23	85	168	173	6	41	101	118	12	35	61	64	3	24	49	51
ecology	9	49	68	69	5	28	42	44	16	119	171	173	8	73	118	118	5	50	64	65	4	38	49	51
microscopy	not measured				3	28	43	44	33	127	168	172	9	59	108	118	6	34	64	65	1	30	45	49
investigate real organs					20	38	42	44	50	120	161	172	38	91	111	118	22	53	60	65	22	40	48	51
Self reported competencies in working with a microscope: 1 very good – 4 not good									13	126	168	174	17	86	118	118	3	24	61	65	6	21	50	50

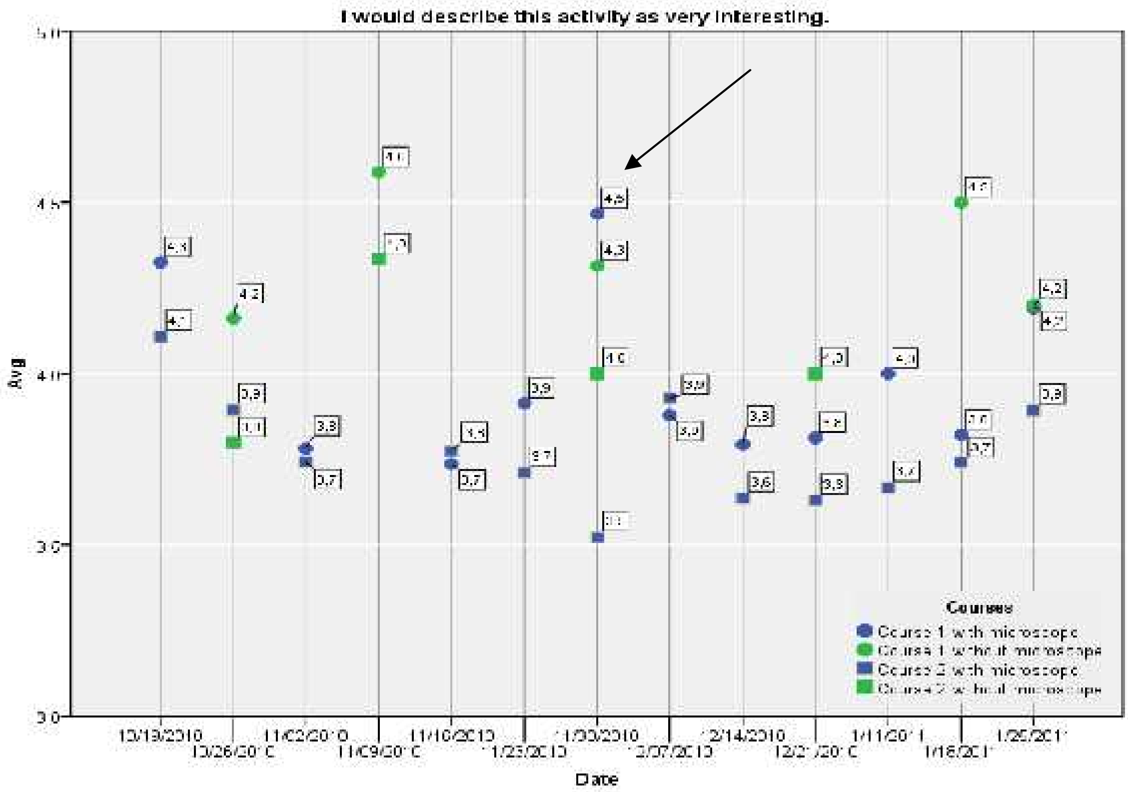
Table 2: Pre-service student teachers´ interests in various areas of Biology

During the first sub-study (summer 2010) a higher degree of self-determination showed positive effects on motivation and interest. When the students worked too often with the microscope, their motivation decreased. The requirement that they draw the observed objects is one reason for the fall in motivation.

Results of the second sub-study (winter 2010) show that motivation during microscopy is high, if lab work is included in problem solving processes and lab work has a high level of self determination. As an example, Figure 1 shows the participants' assessment of interest during winter term 2010.
In November 30th, e. g., they solved problems with the inner ear and with the skin. They had to find out if the "Reissner" membrane consists of one or two layers of cells, and in which layer of the skin there are receptors.

Fig. 1: Motivation during lab work and problem solving

The students often could decide themselves whether they would like to use the microscopy or use another method to discover a scientific problem (*with microscope / without microscope*).



The assessment of the success of their own work correlated significantly with the opportunities for self-determination (Table 3).

The values of the respective interest and self-determination are also closely correlated.

Group 1 and 2 (n=66) winter 2010	Nov.30th perceived competence	Nov. 23rd perceived competence
self determination	.482**	.655**
time which was spent with microscopy	.225	.108
felt pressure	-.544**	-.512**
interest	.413**	.636**

Table 3: Examples for coefficients (Spearman's Rho) for the participants' assessments

However, there is no measurable correlation between the amount of time that was invested in the work with the microscopes during the courses, and the motivation of students.
The perceived burden of the work correlated negatively with the motivation. The students gave the final examination as reason.

There are significant correlations (Spearman's Rho, n=18, oral test / questionnaire) between self determination of one's own knowledge and real knowledge of scientific technical terms (for instance Erythrocyte .493*; Nephron .686**, Alveolar .686**). These results were confirmed in summer 2011.

CONCLUSIONS AND IMPLICATIONS

We are surprised at the information students gave us about their school experiences with microscopy. The students usually assessed their abilities in microscopy in the questionnaire only as mediocre. But in the assessment of the student teachers the microscopy is the learning activity which was more frequently carried out in school than other active and practical learning activities like planning experiments or dissecting organs.

Many students reported that they disapproved of using microscopes especially microscopic drawing. We have to take into account the well-known fact from interest research that school lessons where the topic is frequently re-visited mostly result in less interested pupils.

Where does a single cell begin? Many research participants spoke about their difficulties in orientation between tissues und cell structures. In addition - it seems that there are different types of learners.

Our investigations within the groups of students give first hints on how the skills to use the microscope *for problem solving* can be promoted and how a long-term relationship between person and object could be developed. Students need repeated positive experiences through the use of the microscope.

Fig. 2: Examples of the used microscopes

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A "CLASS DIARY" FORUM TO IDENTIFY PEDAGOGICAL THINKING CHANGES IN PRESERVICE SCIENCE TEACHER TRAINING

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Abstract: The purpose of this study is to analyse the incorporation of the pedagogical contents that were learnt among the messages sent by the students to the class diary forum, and identify the meaningful moments of the shared reflexion process during the implementation of a subject called Learning and Teaching Physics and Chemistry (12 ECTS) in the first year of the Master's Degree Initial Secondary Teacher Training.
We can identified some categories about the meaningful moments of the student shared reflexion process and about references of the students to some pedagogical contents as alternative conceptions, models, problem solving, etc. The lack of references to the scientific contents within the first sessions points out that the pedagogical content was not within their cultural knowledge before the teaching but, after it, the use of these terms were more frequent and it reveals the epistemological and pedagogical thinking changes.

Keywords: Preservice Science Teacher Training; Online class diary forum; students' messages analysis; students' messages analysis; epistemological thinking changes

BACKGROUND

There are a lot of factors that researches highlight in the initial training of science teacher (Loughran, 2007). Among all of them, we will focus on the scientific dimension in order to promote changes in concepts of teachers in the initial training, and to help in the development of ideas, theories, principles, and scientific models more sophisticatedly. Therefore, we enshrine within the development of the pedagogical content knowledge (Berry et al., 2008). This is essential because future teachers will develop: teaching strategy knowledge, understanding the student knowledge, assessing the student knowledge, and knowledge about (purposes) aims and objectives of the topic within the curriculum (Hence et al. 2008).

FRAMEWORK

The present study was developed during the first year of the Master's Degree Initial Secondary Teacher Training (12-18 years old students) in Spain. It was enshrined in the implementation analysis of a subject within the specific module, specialty Physics and Chemistry, called Learning and Teaching Physics and Chemistry (12 ECTS)[1]. This subject had 25 presential sessions of 2.25 hours each last academic year (2009-2010), and it had the following scientific-didactic topic distribution (Table 1).

[1] This specific module also contains a subject called Teaching Innovation and Educational Investigation (6ECTS) which is directly related to the application module (Practicum), and another subject of disciplinary education complement within the specialty (6ECTS).

Sessions	Content
1	Introduction Science Education Aims
2 3	Impediments to change, Spanish National Standards
4	Talking Science Communicative Approach
5	Formative Evaluation in Science
6 7 8 9	Forces and Movements
10 11 12	Models: Sun-Earth
13	Model of parts
14 15	Chemical Change; Acid-Base Models
16	Nature of Science
	Scientific Literacy
17	Problem Solving
18 19	ICT and Science Museum
20 21	Problem Solving
22 23	Practical Works
24	Teaching & Learning models in Science
25	Final Evaluation

Table 1. Content distribution by sessions

The first three sessions were about the problematization of the subject and they were focused around the question "what should a Physics and Chemistry teacher know and be able to do for their 12-to-18-year-old students to learn properly?" The remaining sessions were organised around some blocks of scientific content, since these contents are fresh for the recently graduates and they allow to recognise easily a common thread. In table 2, for each curricular block (scientific content) we show which didactic contents (1-8)[2] could be introduced more carefully (the shady cell shows the block where each science education contents would be covered more carefully).

Scientific content / Pedagogical content	1	2	3	4	5	6	7	8
Sun-Earth Model	X	X			X	X	X	X
Force and Movement	X	X	X	X	X	X	X	X
Properties and structure of matter	X	X		X	X	X	X	X
Energy, transfer and changes	X	X	X	X	X	X	X	X
Chemical Change	X	X	X	X	X	X	X	X
Light and sound	Not implemented for lack of time							

Table 2. Didactic contents developed in each curricular block

Therefore, this organization belongs to an integrated approach between the content and the didactic knowledge. However, it is not only because the didactic knowledge is always based on specific scientific content, but also because among our purposes it is that the Master's Degree students use this opportunity to question, revise and increase their content knowledge.

PURPOSE

Among the activities organised in order to complete the remaining credits online (45h), it is the forum called "class diary". It encourages a collective reflexion process, parallel to the development of the presential sessions. In this forum, open for that aim within the virtual classroom (platform webCT), at the end of each session, the student responsible expressed a brief narrative summary, and not only schematic. In the initial instructions the students were asked to be subjective in their comments, *because they did not have to create an objective and*

[2] 1. Alternative conceptions. Constructivist view of learning. Teaching strategies for conceptual change. 2. Nature of the science and the scientific work. Modelling. Epistemological and attitudinal change. 3. Problem solving. 4. Practical works. 5. Communication in science. 6. Assessment in science. 7. Relations STS and Environment. Sustainability. 8. Selection, sequencing and content organization. Scientific-school knowledge.

impartial report, but to reflect loudly on the knowledge and development of the sessions on classroom.

The purpose of this study is to analyse the incorporation of the didactic contents that were learnt among the messages sent by the students to the forum, and identify the meaningful moments of the shared reflexion process.

METHODS

The virtual platform used in our university allows us to download the messages grouped by sessions, and also to analyse them with a CAQDAS afterwards: computer assisted qualitative; where it can be identified the following categories (table 3) about the meaningful moments of the student shared reflexion process.

About references to the didactic contents:	About the meaningful moments of the reflexion process:
1. Models 2. Talking Science 3. Doing Science 4. Problem Solving 5. Alternative conceptions	1. Epistemological change of thinking 2. School biograhy reflexions 3. Didactic change of thinking 4. Autoregulation moments 5. Formative demands

Table 3. Categories Analysis

RESULTS

In the figure 1 we show the frequency for each didactic contents category, distributed by those sessions in table 2 and identified in the messages sent by the students (N=170) in 22 sessions. It was reduced to 22 because the sessions 18 and 19 did not have diary due to the visit to a science museum and the work with the ICT required more time than the established (10h).

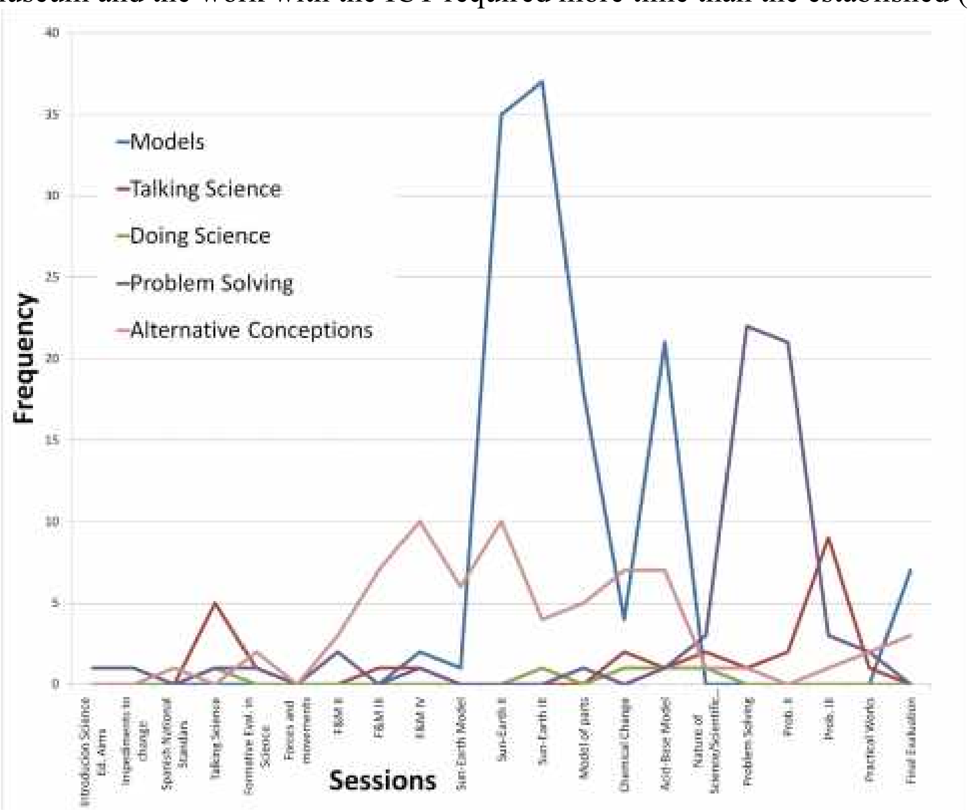

Figure 1. Frequency for each category-II, distributed by sessions

a. Models

In almost all the didactic contents category, the higher frequencies coincide with those sessions related to that didactic content.

The lack of references to the scientific models within the first nine session points out that this didactic content was not within their cultural knowledge. The content appeared from sessions 11 and 12, where they learnt the model Sun-Earth (López-Gay & Jiménez-Liso, 2010). Sessions 13 to 15 were focused on school chemistry models; the use of the term "model" was more frequent. In the last sessions (24 and 25), the messages have been mostly to recognise their pedagogical thinking change; therefore, references to the models are used as a revision of the achieved aims: *the contents have been selected according to the alternative conceptions, and to the big development that they present*.

When experienced in first person the existence of alternative conceptions, the effectiveness of models to explain and predict phenomena, and the innovation experiences presented, it is questionable the necessity of changing the reality in science classrooms: *unfortunately the teaching method is very similar to the one we received and science is not "squeezed" to the maximum, let's see if we change it a little bit...* However, they still recognise a small resistance to the didactic change of thinking: *unwittingly, I insist on keeping approaching the learning process how I was taught*. It expresses the weight of the school experience as an obstacle for the change.

b. Talking and Doing Science

The term 'talking science' only appear in the students messages when specify it on fourth session. However it is present in the majority of the messages through the other sessions and students put special emphasis on it at the end of the course when Problem solving was dealt.

c. *Alternative Conceptions*' data (fig 1) indicates that this term is present in the messages after all the sessions in spite of only we work on it in two of them (forces and movement) and (Sun-Earth model). Students usually specify as self-regulated moments: In this case, we didn't need a pre-test to be aware of alternative conceptions that we have got about this subject (Sun-Earth Model first session).

d. Scientific and Pedagogical Contents as a whole (PCK Integrated model)

When experienced in first person the existence of alternative conceptions, the effectiveness of models to explain and predict phenomena, and the innovation experiences presented, it is questionable the necessity of changing the reality in science classrooms: *unfortunately the teaching method is very similar to the one we received and science is not "squeezed" to the maximum, let's see if we change it a little bit...*. However, they still recognise a small resistance to the didactic change of thinking: *unwittingly, I insist on keeping approaching the learning process how I was taught*. It expresses the weight of the school experience as an obstacle for the change.

CONCLUSIONS AND IMPLICATIONS

Very often researchers that teach in the initial training of science teachers, we make out some indications that highlight that our students are learning how to be reflexive teachers or, on the contrary, the difficulties that they still have. The big majority of these indications can be obtained within the messages our students sent to the forum "class diary". In this study, we have been able to analyse and prove those indications, and identify the key moments where pedagogical and epistemological thinking changes happened.

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SUBJECT KNOWLEDGE AND PEDAGOGY IN PRE-SERVICE SCIENCE TEACHER TRAINING COURSES IN ENGLAND AND WALES

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Abstract: The aim of the research reported in this paper was to explore the extent to which subject knowledge and pedagogy are addressed in one year pre-service science teacher training courses in England and Wales. The study employed a mixed methods approach with progressive focusing between the research instruments. The methods used were document analysis (n=81), university tutor and pre-service teacher questionnaires (n=72 and 245 respectively) and telephone interviews (n=8 and 22 respectively). The main conclusion drawn from the part of the study reported here is that a majority of courses prepare pre-service teachers to teach pupils all three sciences to 16 years. In addition, the minimum degree requirement Higher Education Institution tutors expect for a biological science pre-service teacher is higher than for a physical science pre-service teacher. Nearly one third (31%) of pre-service teachers who categorise themselves as physicists have a degree with minimal or no physics content. One year pre-service teacher training courses do not have sufficient time to equip newly qualified teachers to teach across the sciences to pupils aged up to 16 years and, consequently, there is a need to raise awareness for policy makers and senior managers in schools that continuing support for subject knowledge pedagogy is needed for newly qualified and early career science teachers.

Keywords: Pre-service teachers, subject knowledge, pedagogy

BACKGROUND

Pre-service science teachers on a one year initial teacher training (ITT) course usually have a first degree in some aspect of either the biological or the physical sciences. In many cases their undergraduate study is likely to have been part of a 'pick and mix' modular degree programme which can leave them with a narrow knowledge base of what might be regarded as their specialist subject: biology, chemistry or physics. Few pre-service teachers will have studied all three science subjects to advanced level (18 years). Many may have only studied one science to advanced level and, for these pre-service teachers their study of other sciences will have been limited to general certificate level (16 years). Studies by Lock and Soares (2005), Lock, Soares and Foster (2009) and the House of Commons Children, Schools and Families Committee (2010) suggest that schools require many newly qualified teachers (NQTs) to be competent to teach all sciences to general certificate level. This places a considerable demand on pre-service teachers developing their subject knowledge and ways of transforming this knowledge into effective teaching during a one year ITT course. Even in teaching their subject specialism, pre-service teachers need pedagogical content knowledge to transform good subject matter knowledge into effective lessons (Van Driel, De Jong and Verloop, 2002; Kind, 2009).

A report from the Science and Learning Expert Group (Department for Business Innovation and Skills, 2010) stresses the importance of providing subject-specific training in ITT, specifically recommending that there should be further investigation into:

> *'..the consistency between initial teacher training* [ITT] *providers in the balance between subject-specific and general pedagogical training to ensure that subject-specific pedagogical training receives a high priority.*' (Recommendation 4, p10)

Our research is therefore timely in that it addresses training in subject knowledge and pedagogy in one year pre-service science teacher training courses in England and Wales.
The aims of the research were to explore:

- the extent to which subject knowledge and pedagogy are addressed on one year Science ITT courses
- the ways in which the pre-service teachers acquire and use this subject knowledge and pedagogy
- the extent to which the subject specific course elements meet pre-service teachers' perceived needs for the NQT year.

RATIONALE

Developing into an effective teacher, of say physics, requires more than just the knowledge and understanding of physics content and the generic pedagogy that is applicable to a teacher of any subject.

> *'...just knowing the content well was really important, just knowing the general pedagogy was really important and yet when you added the two together, you didn't get the teacher'*
> (Shulman in an interview reported in Berry, Loughran and van Driel, 2008)

This suggests that a graduate of a particular subject is only likely to start the transformation into a teacher of that subject when they begin to consider how best to teach the subject content in order to make it learnable by others. To account for this, Shulman (1986) introduced the term Pedagogical Content Knowledge (PCK) and proposed that such considerations included analogies, illustrations, examples, explanations, and demonstrations.

While teacher educators and researchers agree that PCK is a useful construct (e.g. van Driel, Verloop and de Vos, 1998; Loughran, Mulhall and Berry, 2008; Kind, 2009), it is also acknowledged that there are differences in its definition and conceptualisation (Nilsson, 2008). Nevertheless, even though PCK appears to be a common component of the teacher knowledge needed to be an effective teacher of a subject (van Dijk and Kattmann, 2007; Nilsson, 2008), it is not a commonly used term by teachers.

Loughran, Mulhall and Berry (2008) proposed a framework called *Content Representations* (CoRes) – key content ideas, known alternative conceptions, known points of confusion, ways of framing ideas to support learning, ways of testing for understanding; and '*Pedagogical and Professional-experience Repertoires'* (PaPeRs) – specific aspects of teaching the topic to explicitly introduce PCK to beginning teachers.

Geddis (1993) proposed that developing teachers need to address pedagogical issues that are content-specific which suggests that to be an effective teacher of physics it is necessary to not only know the content of the various topics (e.g. forces, energy etc), subject knowledge of the topic, but also '*...the particular teaching and learning demands of that particular topic'* (Bucat, 2004, p 217), topic specific PCK.

METHODS

The study employed a mixed methods approach (Tashakkori and Teddlie, 2003) with progressive focusing between the research instruments (Hammersley, 2006). The methods used were document analysis, university tutor questionnaires and telephone interviews and pre-service teacher questionnaires and telephone interviews.

All research instruments were piloted and trialled and the internal consistency of responses and reliability of researcher analysis were investigated where appropriate. The research has been conducted in a thorough and rigorous manner.

Science education tutors (n=160) from 64 universities in England and Wales offering a one year ITT course in science, including biology, chemistry, physics and geology (GTTR, 2009) were informed of the purpose of the study and invited to send course documentation for analysis. Eighty one documents were received from 24 HEIs. This return was representative in terms of geographical spread, type of institution, key stages addressed and science specialism. The documents were analysed for subject-specific training in both the universty and school-based parts of the courses.

Of the 160 university science education tutors, 134 found to be actively engaged in one year ITT courses were invited to participate in an on-line questionnaire. The response rate was 54% (n=72) and tutors from 33 universities voluntarily identified themselves and their institution as willing to be involved in phase 2 of the research. In this second phase tutors (n=8) from six case study universities were selected for interviews and helped to facilitate the completion of the questionnaire by their pre-service teachers (n=245). In each of the six universities up to four pre-service teachers were interviewed by telephone (n=22) having indicated in questionnaire responses that they were willing to participate further. Pre-service teacher questionnaires were administered at the end of ITT year and then interviews conducted in the period leading up to the start of their NQT year.

RESULTS

Selected results from the university tutor and pre-service teacher questionnaires and interviews are presented here.

Data in Table 1 show that most courses (58%) prepare pre-service teachers to teach pupils all three sciences to 16 years. This meets the expectations of many schools and is, in part, made necessary by the shortage of physics and chemistry graduates entering pre-service training.

In an attempt to increase the recruitment of physical science graduates who chose to enter pre-service science teacher training, the minimum class of degree required for physical science graduates appears to be lower than that for biological science graduates (Table 2). Over 50% of university tutors are prepared to accept physical science pre-service teachers with a third class degree or less, whereas only one-third of tutors are prepared to accept these classes of degree from biological science pre-service teachers. This could have serious implications for the proposal to cease funding for applicants with degrees lower than a 2.2 classification (DfE, 2010a) and is likely to reduce even further the supply of physical science teachers.

Training to teach Biol & Chem & Phys to 11-14 year old pupils and…	**n**	**%**
Biol **or** Chem **or** Phys to 14 -16 year olds	6	8
Biol **&** Chem **&** Phys to 14 -16 year olds	11	15
Biol **or** Chem **or** Phys to 14 -18/9 year olds	21	29
Biol **&** Chem **&** Phys to 14 -16 year olds Plus specialism (P/C/B) to 16-18/9 year olds	31	43
Other	2	3
No response	1	1

Table 1. Course content for pre-service teacher training. (Tutor questionnaire)

Minimum class of degree required by university tutors	**Biological science pre-service teachers n (%)**	**Physical science pre-service teachers n (%)**

First	0 (0)	0 (0)
Upper second	6 (8)	0 (0)
Lower second	35 (49)	26 (36)
Third	18 (25)	29 (40)
Ordinary	6 (8)	11 (15)
Other	4 (6)	4 (6)
No response	3 (4)	2 (3)

Table 2. Minimum class of degree required by university tutors for biological and physical science pre-service teachers.

Although 79% of tutors regard class of degree as important (Table 3), tutor interviews revealed that other personal qualities and experiences also contribute to the makings of a teacher and led to offers of places on pre-service teacher training courses to applicants with third class degrees or lower.
Forty-two per cent of HEI tutors regard the institution awarding the degree as unimportant. This finding contrasts with the Government White Paper's apparent focus on good quality graduates from top class universities training to become teachers (DfE, 2010a)

Expectation	Yes	No	No response
Degree class unimportant	15 (21)	57 (79)	0
Institution awarding degree unimportant	30 (42)	42 (58)	0

Table 3. Pre-course subject knowledge expectations (n, % in parentheses).

Nearly a third (31%) of pre-service teachers who categorise themselves as physicists have a degree with minimal, or no, physics content. Data from the pre-service teacher questionnaires show graduates with degree titles that include: psychology, applied microbiology, environmental management, archaeology, forensics and psychology and sports science, training to be teachers of physics.
Evidence from interviews and the document analyses indicates that approaches to addressing subject knowledge and pedagogy are very variable, ranging from no formal support to teaching sessions dedicated to the subject knowledge and pedagogy associated with specific topics such as electricity, photosynthesis and the periodic table.

CONCLUSIONS AND IMPLICATIONS

The main conclusions from this study are that:

- Most courses for pre-service science teachers are preparing them to teach all three sciences to pupils aged up to 16 years.
- the minimum degree classification requirement Higher Education Institution tutors expect for a biological science pre-service teacher is higher than for a physical science pre-service teacher teacher.
- Nearly one third of pre-service teachers who categorise themselves as physicists have a degree with minimal or no physics content.

One year Initial Teacher Training courses do not equip newly qualified teachers to teach all sciences to pupils aged up to 16 years. There is a need to raise awareness for policy makers and senior managers in schools that continuing support for subject knowledge and topic specific pedagogy is needed for newly qualified teachers and that this support should continue into the early years of their careers.

In view of the varied practice in addressing subject knowledge and topic specific pedagogy there is a need for university tutors engaged in Initial Teacher Training to share practice. However, opportunities for sharing practice have declined due the demise in 2010 of support from both the Regional Science Consortium meetings and the National Strategy Science Team. This gap could be filled by the Association for Tutors in Science Education, through the Association for Science Education, by extending their role to facilitate the sharing of practice through their journals, annual research conference and website.

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USING SLOWMATION TO MAKE SCIENCE PRE-SERVICE TEACHERS` BELIEFS EXPLICIT

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Abstract: Universities in Bremen (Germany) and Melbourne (Australia) researched the use of Slowmation in their pre-service science teacher education courses to investigate its effectiveness in making pre-service teachers' beliefs explicit. In Germany, pre-service teachers in a chemistry course made Slowmation movies of their beliefs of effective teaching of chemistry. They presented their Slowmation movies to their peers and discussed the similarities and differences in the beliefs they saw. In Australia, pre-service teachers learnt Slowmation and used it on their teaching practicum with their pupils. On their return to university the pre-service teachers showed their Slowmation movies to their peers and discussed their teaching of it. Data was collected by video-recording the presentations and discussions, and using questionnaires. In both countries Slowmation proved effective in engaging pre-service teachers in discussions of their beliefs of science teaching and learning. Identifying pre-service science teachers' beliefs should be an important part of science education courses and Slowmation had proved a useful teaching procedure that makes explicit pre-service teachers' beliefs of what constitutes effective science teaching.

Keywords: Pre-service teachers' beliefs, teacher education, Slowmation

THEORETICAL BACKGROUND

Research in science education has been focusing on students' and teachers' beliefs for many decades. Such research began with researchers investigating the different beliefs related to specific scientific content, such as Bandura (1986) who found that beliefs tend to be the best indicator of one's personal behaviour. Expanding on this idea, Pajares' (1992) reported that beliefs played a crucial role in not only defining personal behaviour, but also in the way a person organized their knowledge and information. Taking this one step further, we can assume that pre-service teachers' beliefs affect both their learning and their understanding of teaching throughout their teacher education program (Fischler, 2000). On the other hand, pre-service teachers also have to be prepared to understand and know about their pupils' beliefs about a multitude of scientific topics. However, at university it is not possible to study all possible alternative conceptions pupils may have about each and every scientific topic. In our science education courses we have been searching for ways to make pre-service teachers' beliefs explicit, have them reflect on these and then build into the course ways that will have them reconsider their beliefs about what is effective teaching and learning in science. Dewey (1933) stated: "Reflection is an active, persistent, and careful consideration of any belief or supposed form of knowledge in light of the grounds supporting it and future conclusions to which it tends" (p. 6). This research examines whether Slowmation as a new teaching procedure can be effective in making explicit the pre-service teachers beliefs of science and the teaching and learning of science across two countries.

Slowmation is a 'Teaching Procedure' (Mitchell, 2007) based on elements of clay animation designed to engage students in constructing ways of demonstrating their understanding of science concepts and science ideas. In contrast to clay animation where clay or plasticine figures are photographed and shown quickly to simulate continuous 'near life' movement, Slowmation uses a variety of materials and is played at 2 frames per second to produce "slow animations" (hence the term Slowmation). In this study, the Slowmation process was introduced to preservice secondary science teachers who made short movies about abstract science concepts. The purpose of using Slowmations in this way with preservice science teachers was in order to explore their understanding of science concepts. In so doing, it was anticipated that they might see the value in using the procedure with their students when they were teaching (on their practicum) and therefore gather insights into their students' understanding of science concepts (see Keast, Cooper, & Bullard, 2011 for discussion of one such case).

Slowmation has been pioneered by Hoban (Hoban, 2007; Hoban & Ferry, 2006; Hoban, McDonald, & Ferry, 2009) at the University of Wollongong through extensive work with Primary pre-service teachers over several years with a major goal of producing useful classroom resources in science. The Slowmation process has proven to be remarkably successful in engaging pre-service teachers with some participants spending upwards of 20 hours outside of scheduled class time to produce movies to be shared through an online forum. Hoban's work led to a successful Australian Research Council (ARC) Discovery Project (Hoban, et al., 2008) spanning three universities (Wollongong University, Monash University and University of British Columbia) and two continents (Australia and Canada).

RATIONAL

Slowmation (Hoban, 2005, 2007) is not a software package, rather it is a 'Teaching Procedure' (Mitchell, 2007) based on elements of clay animation designed to engage preservice teachers and pupils in ways of demonstrating their understanding of concepts and ideas by creating simple animated movies. In contrast to clay animation where clay or plasticine figures are photographed and shown quickly to simulate continuous 'near life' movement, Slowmation uses a variety of materials and is played at 2 frames per second to produce "slow animations" (hence the term Slowmation). Our paper presents two different uses of Slowmation in science teacher education. The data was collected in two countries: Germany and Australia and while both countries differ in their teacher education system this paper demonstrates how Slowmation can be used in very different contexts.

The research questions guiding this research were:

> *Can Slowmation be effective in making explicit the pre-service teachers` beliefs of science and teaching science across in Germany and Australia?*
>
> *How do pre-service teachers react to utilising Slowmation as a part of their teacher training?*

SAMPLE AND METHOD

In Germany, chemistry pre-service teachers developed Slowmation movies as a part of their seminar "*Diagnosis and Planning of Chemistry Lessons*". Slowmation was used to make chemistry pre-service teachers' beliefs about chemistry teaching and learning explicit for them. There were 21 German chemistry pre-service teachers who took apart in this study, and they were in the fifth semester of their course and were preparing for a one month school internship. The pre-service teachers are almost at the end of their Bachelor Degree and have completed 60 hours university practicum in secondary schools for one other subject (mainly biology). One of the aims of the present seminar is to make pre-service teachers` beliefs about teaching and learning explicit so that can reflect on them. Starting from this aim, pre-service teachers had the opportunity to become acquainted with the method of Slowmation and to reflect upon its use as a teaching procedure in their chemistry classes. They made their movies about their ideal chemistry lesson in groups of two, with time at home over one week to finalize production and presented them in class at the next tutorial. After the Slowmation movies had been presented, the pre-service teaches discussed the similarities and differences in the beliefs presented in the each Slowmation movie. The data was collected from a qualitative perspective by the first author during this class. The first set of data collected was the observation of the pre-service teachers and consisted of detailed field notes made during the first seminar session while pre-service teachers were planning their Slowmation. The second data set was collected comments from pre-service teachers when they presented their Slowmation to the class. The third and final data set from Germany consisted of collecting pre-service teacher responses to an open ended questionnaire.

In Australia, 24 preservice teachers developed Slowmation movies as part of their course work, and introduced Slowmation into their science classrooms during their school practicum. On their return to university following this practicum the pre-service teachers presented the Slowmations created by their students to their colleagues and lecturers, and discussed the impact of introducing this procedure on their students' learning about science concepts. In Australia, the research also took a qualitative approach and data was collected by video recording the presentations and analysing them for themes. (for more detail of this ongoing research see Keast, Cooper, Berry, Loughran, & Hoban, 2008; Keast, Cooper, Berry, Loughran, & Hoban, 2009; Keast, Cooper, & Hoban, 2010a, 2010b). The purpose of using Slowmations in this way with pre-service science teachers was for them to explore their beliefs and understanding of teaching and learning science. In so doing, their discussions of their teaching Slowmation in school covered many of the big ideas outlined in the Australian course which the authors believe built on their growing understanding of their pedagogical context knowledge (Morine-Dershimer & Kent, 1999).

In both contexts and in the two countries, the authors focus on their pre-service teachers' reflections on their beliefs of science and teaching and learning science through the use of Slowmation, rather than focusing on the technical usage of Slowmation or producing polished finished product. In this way Slowmation was a catalyst for generating reflection and discussion of the pre-service teachers' beliefs about teaching and learning science.

RESULTS AND DISCUSSION

Germany:

Slowmation was a new teaching procedure for the German chemistry pre-service teachers. However, they were open to the use of this new procedure and could see benefit in its use for their teaching. From the beginning, it was easy to see that chemistry pre-service teachers like the method of Slowmation and see it as a hands-on, innovative and novel procedure compared to the other education courses and seminars they had been involved into this point.

During the making of the Slowmations, it was interesting to see the discussion between the group members that developed one movie. Already the participants noticed that they had different beliefs about what constituted an effective chemistry class and needed to negotiate what aspects were to be included. They started their discussions from the position of the teacher in the classroom, moved on to the role and craft of experiments (from both the teacher and student perspectives), and then discussed more detailed issues of teaching and learning. In some cases they discussed the role of the media (TV and Laptop) in the chemistry classroom and importance of how it is best to use such technologies. However, the topic was that each group should make one Slowmation of effective chemistry teaching. To do so, the participants of each group needed to agree to one example of teaching and it was during these discussions that the pre-service teachers began to explain to each other their own beliefs. Such discussions brought considerable argument and justification for having such beliefs and led to in-depth explanation of the individuals' position. On the one side pre-service teachers were arguing from educational perspectives (constructivism, scientific literacy) to explain their beliefs about how an effective chemistry classroom should be presented. On the other side, one pre-service teacher spoke of his experience in classes and the need to be more pragmatic. This pre-service teacher was older than his peers and had 2 years experience working as a chemist in a German chemical company. After he started as a chemistry teacher in the lower secondary level, he decided he needed a chemistry teacher training program to improve his understanding of the educational theories he thought he was lacking. However, he was very different in his beliefs which were so dominantly influenced by his teaching experience. He repeated often:

> *Yes, that is what is written in a book. But, believe me; the kids are not like in a book. So you cannot be like that and must handle it differently. (Student T, Germany)*
>
> Or
>
> *That would never work in my class. You have to have the control in your classroom. That is also what my colleagues say. (Student T, Germany)*

This pre-service teacher was very resistant to change his beliefs about effective chemistry teaching and the ideal chemistry classroom. Other pre-service teachers in this group, and other groups were more open for reconsidering their beliefs in light of the position and arguments of other group members. Finally his group made a Slowmation that was a compromise of the range of different beliefs the group had. Presenting their Slowmations, the pre-service teachers were surprised with the range of different beliefs about effective teaching that were presented by their class peers. The pre-service teachers in this study were paying attention mainly to the role of the teacher in the classroom, the student-activities and the role of experiments in the presented scenarios. One revelation came from a pre-service teacher in regards to position of the teacher in the room and the implications of student centred versus teacher centred teaching:

> *In all of the movies I was paying attention to a teacher. It was so funny to see in the last movie, that the teacher was all the time somewhere at the side. In one moment I was thinking "he is doing nothing!". In my movie, me as a teacher was doing something, I was having contact to my students all the time. I was in the middle of the classroom. From this I realised I liked to be in control and didn't run a student-centred classroom. (Student K, Germany)*

The response showed that the preservice teacher needed to be in the middle of the learning, they did not believe that effective teaching would allow the students to be the centre of their own learning. The questionnaire showed that the pre-service teachers saw Slowmation as an effective method for making their beliefs explicit and a helpful approach for discussing the alternative views about teaching and learning. The chemistry pre-service teachers in this study see Slowmation as a new, innovative and creative procedure for their teacher education course. They thought the preparation of the Slowmation was a long process (especially for those who were not familiar with the computer program Windows MovieMaker). However, they were willing to make the movies again and see the future use of Slowmation as effective in their chemistry classes.

Australia:

The classroom presentations and discussions of school students' Slowmation movies post practicum provided valuable feedback to the preservice teachers about their beliefs about teaching and their students' learning.

> *Slowmation includes a good learning situation for my students because they had to translate the material from 2D (dimensional) (the pictures in the text book) to 3D (models for the movie). But also when they are deciding what to do, they are discriminating between what is important to show in the movie and what is not. And that to me is the real learning. (Student J, Australia)*

In this comment the preservice teacher articulates what she believes is the real learning in her classroom. For her Slowmation created opportunities between her students in their individual groups to discuss what was important in the science process and how they understood the science. Learning also occurred as students translated information from the text and 2D diagrams into 3D models and then animated these. Mitchell (2007) describes such work as translation tasks, "Students are asked to translate a piece of information from one form into another. The process helps students to actively process what they know and to identify what they don't know. Because this task can be tackled in many ways, it provides an opportunity for student choice and independent decision-making …" (p.15). Slowmation allows students the choice of how they represent the science concept and in animating it they start to understand the process as they move between stages.

Another preservice teacher commented:

> *These students were never asked to consider themselves as learners or to recognize their own learning. I feel this is very important. (Student M, Australia)*

Making learning explicit and helping students recognise when they were learning and how they were learning was a belief about science learning that was revealed by this student during her presentation. The Slowmation presentations allowed preservice teachers to share their classroom experiences through the artefacts that replayed the students understanding. In this way the preservice teachers discussed issues of learning that are otherwise difficult to explicate in the classroom.

Another preservice teacher was concerned with teaching science systems as isolated rather than as belonging to a larger interconnected system:

> *Students should probably show how systems interact and make those links between systems; like the students doing the digestive system [here] should show how that system is impacted by other systems. They shouldn't be taught in isolation. (Student A, Australia)*

In each of these examples the Australian students have not only recognised important features of science learning, but they have also articulated publicly and with conviction their beliefs about what constitutes effective learning in their science classrooms.

CONCLUSIONS AND IMPLICATIONS

From different studies we know that pre-service teachers' beliefs can be influenced and developed during the teacher education program (eg. Markic & Eilks, 2010). It is clear from the present study that Slowmation was an effective teaching procedure to make explicit pre-service teachers' beliefs about science and teaching and learning science. Not only did pre-service teachers get to know new methods for reflection and self-reflection, they were also motivated to do so and enjoyed doing it. Seeing their colleagues' alternative beliefs led these pre-service teachers to think carefully about their own beliefs in light of the thinking of their peers. Pre-service teachers were given the opportunity in each country to discuss their own beliefs with their colleagues, think about their own beliefs and compare them with those of their peers. The authors see pre-service teachers making their beliefs public as the first step in the process of changing beliefs. Teaching procedures such as Slowmation should be incorporated more often in university teacher education programs to make explicit the beliefs of pre-service teachers. Furthermore, the knowledge and insights into pre-service teachers' beliefs can help science educators to better understand their students and the beliefs they bring about teaching and learning to their units. This allows teacher educators to plan their lecturers and tutorials in ways that challenge and hopefully in time change such beliefs. Finally, the authors believe that the adoption of Slowmation has been useful in both Germany and Australia to make explicit pre-service teachers' beliefs and should be considered as an effective procedure to be used by other teacher education programs.

In the Australian context, Keast and Cooper started using Slowmation to make explicit pre-service teachers` beliefs and their research has developed into pre-service teachers using such beliefs to situate their 'Pedagogical Knowledge' (Morine-Dershimer & Kent, 1999). Keast and Cooper's learning as both as researchers and teacher educators had been influenced by the knowledge they have constructed of their practice and that of their pre-service teachers understanding of teaching science by using Slowmation. As they look at Markic's work here, they look back at where they were several years before. Through reflection on their research, their practice of teaching with Slowmation has changed to elicit more from their students about their understanding of science teaching. As Dinkelman et al. (2006) suggest, "developing an identity and a set of successful practices in teacher education is best understood as a process of becoming" (p.6). Keast, Cooper and Markic believe that Slowmation can be a useful tool to improve and advance this "process of becoming" for those science teacher educators who use it in a purposeful way to reflect on their own practice and understandings of teaching about teaching science.

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COMPARISON OF GERMAN AND MALAYSIAN PRE-SERVICE SCIENCE TEACHERS BELIEFS` ABOUT TEACHING AND LEARNING

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Abstract: Research on teachers` beliefs is considered to be more important in science education. Teachers` beliefs constantly influence their acting in the classroom. It can be assumed that the beliefs pre-service teachers hold in prior to their training and while taking courses will influence their understanding of how to teach during their training program. Research in this area has focused either on (i) one specific group of pre-service teachers or (ii) one specific aspect of the pre-service teachers' beliefs. Furthermore, most studies are applied within one country, with respect to one educational and cultural background. The study aims to compare data from Malaysian and German pre-service teachers who are at a comparable stage of their teacher training. The same questionnaire was administered to pre-service teachers in both countries. The questionnaire required the pre-service teachers to draw themselves and their students in a typical science classroom situation. Data was analyzed based on Grounded Theory to offer holistic insights into the beliefs about teaching and learning. Data shows that the pre-service science teachers in both countries hold quite modern beliefs about teaching and learning. Furthermore, while the German group seems to be more homogeneous about their beliefs, the group from Malaysia is more heterogeneous. The cultural influences and implication for the science teacher education for both countries will be discussed.

Keywords: pre-service teachers`s beliefs, Germany, Malaysia, teacher education

FRAMEWORK AND OBJECTIVES

Beliefs play an important role in how teachers organize knowledge and information and are essential in helping teachers adapt, understand, and make sense of themselves and their world (Schommer, 1990). How and what teachers believe have a tremendous impact on their behavior in the classroom (Pajares, 1992; Richardson, 1996). As teachers` beliefs connects to teacher's practices (Richardson, 1996), therefore, the belief teachers hold should influence their classroom judgments and actions. Hence, better understanding about teachers` beliefs is essential to improve teaching practices (Pajares, 1992; Richardson, 1996) since teacher's belief provides a true window to look at their decision making and instructional practices (Nespor, 1987; Pajares, 1992). Teachers` beliefs influence how teachers' present science in their classrooms and the kinds of opportunities they provide for students to learn science (Roth et al., 2006). Therefore, research on teachers' beliefs has been considered as essential in science education. The pre-service teachers` beliefs which are deeply held, and often unexamined, need to be sought out by teacher educators to provide pre-service science teacher with ample opportunities to develop a teaching and learning science classroom that are aligned with current reforms. The pre-service science teachers' beliefs need to be developed into the direction that science should be taught accordingly within the recent context. Fenstermacher (1979) argued that one goal of teacher education is to help young teachers transform tacit or unexamined beliefs about teaching, learning and the curriculum into objectively reasonable or evidentiary beliefs.

Markic and Eilks (2010) analyzed the beliefs of 85 German chemistry pre-service teachers about chemistry teaching and learning at the beginning of their teacher education. The majority of chemistry pre-service teachers from this sample showed teacher-centered beliefs. In contrast, the modern theories of learning and instruction are based on a framework of constructivism which calls for student-centered teaching approaches. Tanase and Wang (2010) study the transformation of initial epistemological beliefs of four pre-service teachers on one teacher education classroom course. Study suggests that participants' epistemological beliefs about learning could affect their teaching and the transformation of their beliefs could also lead to the change of their teaching ideas and practice. Also, a conceptual change of pre-service teachers is only possible through a long-term process. Yilmaz-Tuzun (2008) examines the 166 pre-service elementary teachers' beliefs about science teaching from three Midwestern universities. In this study, he explored the pre-service elementary science teachers' beliefs regarding self-reported comfort level about their abilities to apply traditional and reform-based teaching methods, utilize assessment strategies and classroom management techniques, and teach science content. It was assumed that pre-service teachers' belief systems and the knowledge they gained through methods courses are in relation with their further teaching experiences.

This study stems from different educational backgrounds and educational systems. Furthermore, the political system, culture and the state religion are also in most of the cases not comparable. On the other hand, the instruments used in the different countries are not the same and focus on different beliefs and beliefs systems. However, most of the studies in this research area are focused either on (i) one specific group of pre-service teachers or (ii) one specific aspect of the pre-service teachers' beliefs. The present study adopts the instrument and evaluation pattern presented in Markic and Eilks (2010) to look into the pre-service science teachers` beliefs from different educational and cultural backgrounds. The study compares data from Malaysia and Germany`s pre-service teachers which are at a comparable stage of their teacher training. The general research questions of the present paper are:

(1) What general conclusions can be drawn about the beliefs of science/chemistry pre-service teachers in Malaysia and Germany?
(2) Are there any differences in beliefs that Malaysian and German science/chemistry pre-service teachers hold about teaching and learning?

METHOD AND SAMPLE

In this qualitative case study, participants were instructed to draw themselves as science teachers in a typical classroom setting found in their chosen subject and to answer four open questions. This idea relates to the 'Draw-A-Science-Teacher-Test Checklist' (DASTT-C) (Thomas, Pedersen & Finson, 2001), supplemented with questions about teaching objectives and previous activities. Development of the data analysis pattern occurred using Grounded Theory (GT) as described in Markic, Eilks and Valanides (2008). The core category based on GT is the range between the predominance of more traditional versus more modern teaching orientation in line with educational theory. Three 5-step scales were developed with a GT focus on 1) *Beliefs about Classroom Organization*, 2) *Beliefs about Teaching Objectives* and 3) *Epistemological Beliefs*. The validity of the data was achieved through independent rating and searching for inter-subjective agreement (Swanborn, 1996). The evaluation pattern developed using GT does not present a linear scale. The numbers are only the symbols for the descriptions that are made along the data. The short description of the three categories is presented in Table 1. More detailed information can be found in Markic et al. (2008).

	Traditional view		**Modern view**
Belief about Classroom Organization	The classroom activities are mostly teacher-centered, directed, controlled and dominated by the teacher.	↔ -2, -1, 0, 1, 2	Classes are dominated by students' activity and students are able to choose and control their activities.
Belief about Teaching Objectives	The focus of science teaching is more or less exclusively focused on content learning.	↔ -2, -1, 0, 1, 2	Learning of competencies, problem solving or thinking in relevant contexts are the main focus of teaching.
Epistemological Beliefs	Learning is passive, directed and controlled by dissemination of knowledge.	↔ -2, -1, 0, 1, 2	Learning is a constructivist, autonomous and self-directed activity.

Table 1: An overview of the three scales

The sample of the present study contains Malaysian and German group of science/chemistry pre-service teachers which are at the comparable stage of their teacher education program.

<u>*Malaysia*: </u>The sample consisted of 43 pre-service teachers from Universiti Sains Malaysia. Subjects were third year of Science Education Degree Program enrolled in the chemistry teaching methods course. The course is compulsory for students who chose chemistry as their major/minor subject. The course focuses on delivering instructional strategies and educational theories that form the framework for teaching and learning chemistry. The course was conducted for one semester consisting of 14-weeks.

<u>*Germany:* </u>The German group of pre-service teachers (N=31) was halfway through their 5-year university education program. This group had already had several chemistry lecturers and seminars, including some education and science education courses. The participants had just returned from a half-year teaching internship in school. The pre-service teaches are mostly between 21 and 25 years old and there is a balance between male and female in this group. A majority of pre-service teachers are coming from the North part of Germany and got their requirement for university administration at German grammar school.

However, in both cases, the selection of this data sample was not representative in a statistical sense. Nevertheless, most of the Malaysian and German pre-service teachers possess similar formal qualifications for access to university study. The age and gender distributions were very prototypical for similar groups of pre-service teachers in the respective subjects. Using this point-of-view as a springboard, there is no sound reason to assume that these pre-service teachers are uncommon in any respect. There can be no obvious assumption that the results would differ significantly by sampling a new test group from other German universities involved in science teacher education. Through selection of the sample, this case study remains valid as to its source of information, allowing careful analysis of pre-service teachers' beliefs in the sciences all over Germany.

RESULTS AND DISCUSSION

All three categories were interpreted as representing a range between more traditional and more modern beliefs with regards to educational theory and research evidence (see Markic & Eilks, 2008).

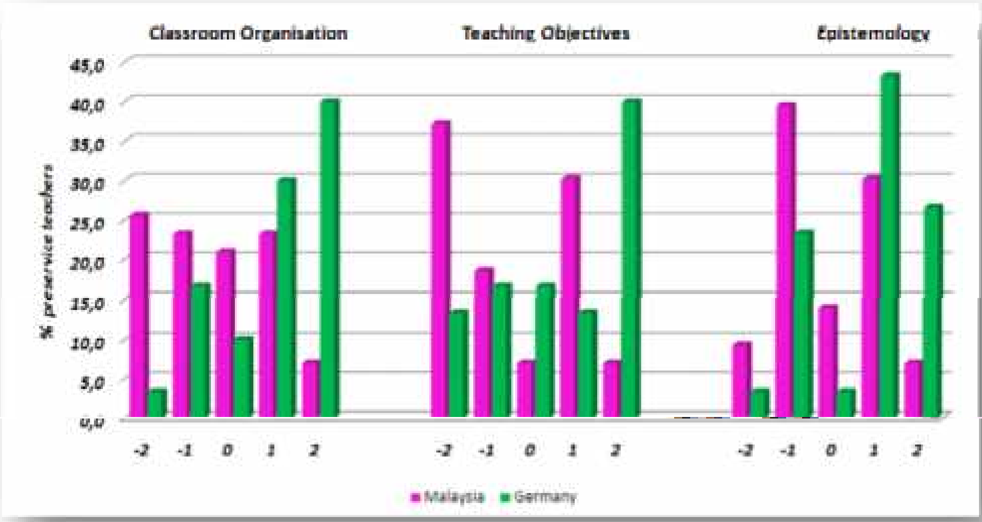

Figure 1: Visualization of the percentages for the three categories

The results in Figure 1 represent a broad diversity of beliefs within the group as a whole, but also show contrasts within the respective pre-service teachers from Malaysia and Germany.

The Malaysian pre-service science teachers tend to hold more teacher-centered beliefs when it comes to teaching and learning science. Concerning *Beliefs about Classroom Organization* this group seems to be most heterogeneous, though there is a slight tendency to teacher-centered classroom organization. The data presented for *Beliefs about Teaching Objective* is heterogeneous but not as the first category. Roughly 60% of this group illustrates that teaching science is preferred to be exclusively content-structure focused; with learning content is the central objective. Finally, for the *Epistemological Beliefs* Malaysian pre-service science teachers` beliefs are in balance. All pre-service science teachers show highest numbers at code -1 and high at code +1, other codes show low frequency. Code -1 illustrates that learning science is even though over-directed with student-active phases but still follows a storyboard written by the teacher. Learning though conducted by the students but still organized and directed by the teacher.

The German chemistry pre-service teachers tended to hold more modern beliefs when it comes to chemistry teaching and learning. Furthermore, this group of pre-service chemistry teachers seems to be more homogeneous in their beliefs about chemistry teaching and learning. The analysis of German group shows heterogeneous allocations for all three categories, but especially for *Beliefs about Teaching Objectives.* Those beliefs are describing the knowledge of competencies and problem solving as a main focus of teaching. Additionally, students` thinking in relevant contexts and other affective outcomes are the main objectives of the lesson. Furthermore, in the other two categories, this group leaned quite strongly towards student-centered. German chemistry pre-service teachers bring more modern teaching and learning at this stage of their teacher education program. These beliefs are characterized by student-centered classroom organization and constructivist learning.

Another important aspect of the data is related to interpreting the data combinations found among the three categories. If a pre-service teacher shows similar classifications in each of the three categories, then the combination of codes will appear along or near the diagonal line from (-2/-2/-2) to (2/2/2) in 3D-diagram. The code combinations for the both countries are represented in Figure 2.

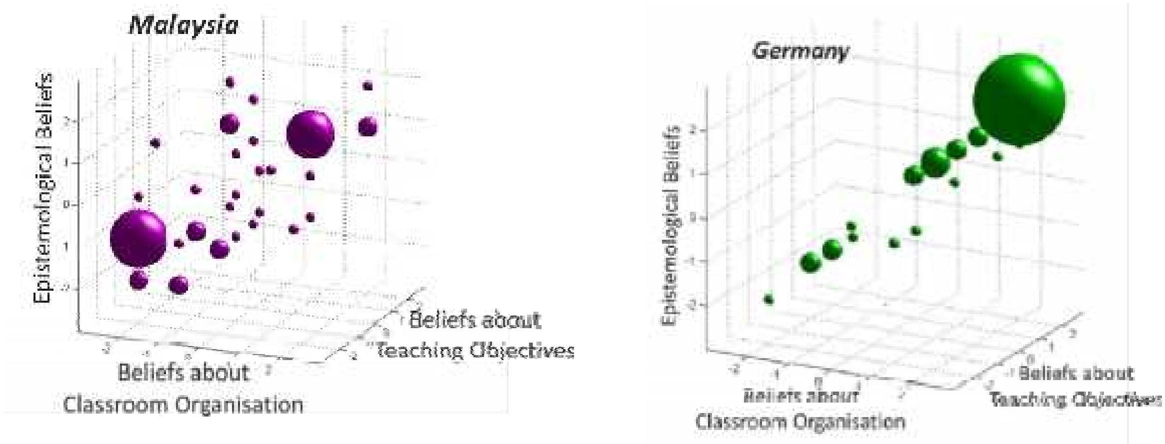

Figure 2: 3D-representation of the code combinations for both countries

Figure 2 shows a high proportion of pre-service teachers' code combinations for both countries occurring near the spatial diagonal. This means that the beliefs tested are interdependent upon one other (see also Markic & Eilks, 2008). Furthermore, the closer a pre-service teacher's code combination approaches the lower, left, front most portion of the three-dimensional plot, the more traditional the pre-service teacher's beliefs about teaching and learning will be. The nearer a code combination approaches the upper, right, hindmost corner of the diagram, the more the pre-service teacher's beliefs fall in line with modern educational theory.

Malaysian pre-service science teachers tend to hold a broad diversity of beliefs about science teaching and learning. A very large number of the collected data in Malaysian group appears in the lower, left, frontal part of the diagram. However, almost the same number of pre-service teachers` code combinations in this group is anywhere near the upper, right, back part of the diagram. Contrary to this result, German chemistry pre-service teachers are more homogeneous in their beliefs about teaching and learning of chemistry in the middle of their teacher education program. Most of the pre-service teachers in German group show results which are located in the upper, right, back part of the diagram. This indicates beliefs remaining more in line with modern educational theories. This group favors by the majority student-centered approaches, including ideas stemming from constructivist learning, and an orientation towards scientific literacy objectives.

CONCLUSION AND IMPLICATION

There are noticeable differences between the two groups of pre-service science teachers studied. Whereas German pre-service teachers are more homogeneous (with the group tending towards modern educational ideas), Malaysian teacher trainees show a much more diverse range of diverging beliefs, which are widely scattered between traditional and modern ideas about teaching and learning in Science. It would seem that many pre-service teachers in Malaysia do not hold beliefs consistent with modern educational theories and methodologies.

There are differences between the two groups of science/chemistry pre-service teachers to see. While the German pre-service teachers are more homogeneous as a group and hold more modern beliefs about teaching and learning of chemistry, Malaysian pre-service teachers groups is at the comparable stage more heterogeneous showing traditional and modern beliefs about teaching and learning as well. Here we can say that it seems that in Malaysia not all of the pre-service teachers see themselves teaching in line with modern educational theories. In Germany the development and modern/student-centered beliefs are one part of the university teacher education program, not only in courses and seminars, but also in teaching internship at school. At this point, it is to say, that this study should be an impulse for thinking about changes in science teacher education program in Malaysia. It seems that the seminars and courses in Malaysia are not sufficient in line with modern teaching and learning theories. It is to think about how the (potential) developed traditional beliefs during the own time as a pre-service teacher should be reflected, changed and developed. Thus, university seminars and lecturers are needed, who base their efforts on modern research theories and discuss theoretical aspects of their fields, can and do influence pre-service teachers` belief system in a more modern attitude.

From other studies we know that German pre-service teachers generally have more traditional beliefs at the beginning of their tertiary education (Markic & Eilks, 2008), but that those beliefs can be altered during the course of the teacher education program (Markic & Eilks, 2010). Starting there, one possible explanation for the differences in results among German and Malaysian teacher trainees might be explained by the different teacher education programs in both countries. It seems likely that education programs geared towards higher levels of pedagogy and science education from the first semester onward - as is the case in Germany - can influence pre-service teachers' beliefs about education in a more modern attitude. One question which immediately arises is whether Malaysia might also reap similar rewards by including a focus on such coursework in the early phase of teacher trainee educational programs. This might allow Malaysian teacher trainers to instigate an early, sustainable change in their pre-service teachers` beliefs about teaching and learning. Further research will be required to investigate this aspect.

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THE COGNITIVE AND LINGUISTIC SKILLS ASSOCIATED TO HUMAN NUTRITION IN TEACHER TRAINING

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Abstract: The aim of this study is to find out the importance that trainee Primary and Secondary teachers give to the evaluation of certain cognitive and linguistic skills in relation to certain key ideas associated to human nutrition and to what extent they identify these skills in the evaluation questions asked. 270 questions were analyzed, proposed by 54 groups of teachers during a training activity included in the theme of evaluation. The educational importance of the use and development of these aforementioned skills were previously dealt with. The results show that the future teachers give more importance to the description and definition than to the justification. Moreover, differences can be seen depending on the key idea being considered and, at times, depending on the group of teachers. It can also be seen that the teachers are not always aware of the skill they require in their questions. This shows that attention should be given to this area in teacher training as justification is essential for the understanding of the subject of human nutrition, in Primary as well as in Secondary.

Keywords: Cognitive and linguistic skills. Human nutrition. Teacher training. Primary. Secondary.

INTRODUCTION

In recent years the importance of language in scientific learning has become clearer, in how it allows ideas to be expressed and organized (Rivard & Straw, 2000; Jiménez Aleixandre, 2003; Prain, 2006). An important objective of scientific education is for students to be able to give scientific explanations. In coherence with scientific discourse, students have to use the language in an interpretive manner (Sutton, 2003), taking a certain theoretical framework as a reference. This requires the use of cognitive and linguistic skills that have different levels of difficulty (Jorba *et al* 2000). Amongst these are included: a) the description of facts and processes, "how it is, what's happening"; b) the definition of a concept, necessary for identifying it, "what it is" and c) the justification of the facts/processes, "why it is, why it is happening".

It would be desirable for teaching to promote the use of the aforementioned skills in relation with specific contents, with the questions being asked in the classroom being a key element in their development. However, the activities included in Spanish textbooks for the study of human nutrition usually focus more on the anatomical and functional descriptions of the systems involved or on the description of the different types of food, but little attention is paid to the justification of the function itself or to the importance of a particular diet (García Barros & Martínez Losada, 2005). Teacher training constitutes one of the most ideal systems for overcoming these problems. Such training should take into account the cognitive and linguistic skills involved in scientific learning, as well as the thinking of the trainee teacher with regards to these, with the aim of promoting their professional development (Hewson *et al*., 1999).

This study aims to find out: a) which skills the trainee teachers of Primary and Secondary consider to be important in relation to specific contents of human nutrition and b) to what extent these teachers identify these skills in the questions asked.

METHODOLOGY

270 evaluation questions have been analyzed, proposed by 54 groups of trainee teachers (32 groups from Primary education and 22 from Secondary education). Each group was made up of two students.

The questions were written in the context of an initial training course for Science teachers and, more specifically, during a training activity included in the theme of evaluation. In a previous subject we presented and discussed the educational value of cognitive and linguistic skills required by the questions which are asked in the classroom. Each group had to propose five questions directed at evaluating the learning, achieved by some hypothetical Primary and/or Secondary students, relating to four key ideas, associated with nutrition in humans and that had supposedly been dealt with previously in the class: a) Human nutrition – nutrition as a vital function; b) Implicated systems – anatomy, function and specific processes of each system; c) Food – types and functions of food/nutrients; d) Food and health – characteristics and the importance of healthy eating. They were also advised that they had to decide the degree of difficulty of the questions and they were reminded of the possibility of requesting a description, definition or justification.

The questions contributed by the teachers were grouped both according to the skill it requires (description, definition or justification) and according to the key idea it dealt with (human nutrition, implicated systems, food or food and health).

FINDINGS

All the groups of Primary and Secondary trainee teachers asked at least one question that required a description and around 90% of each group asked some question that required a definition (Figure 1). Practically all of the Secondary groups asked at least one question that required a justification. Only 47% of the Primary groups asked for this skill.

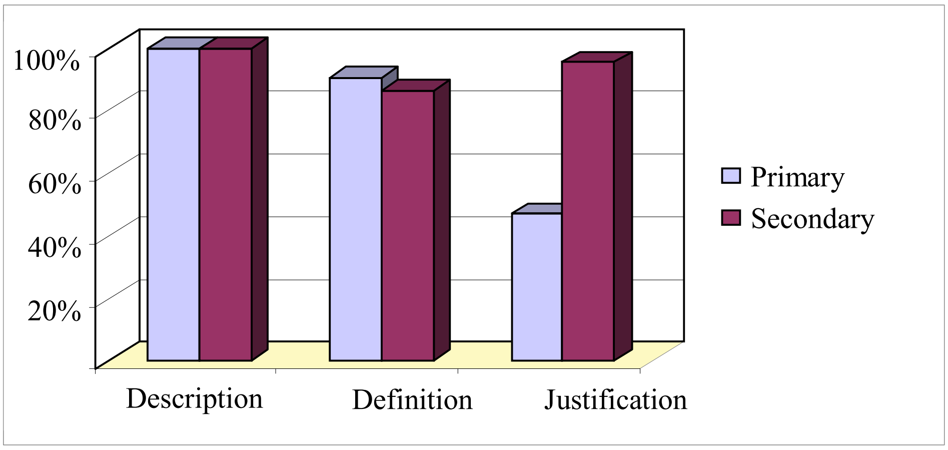

Figure 1: Percentage of groups that required various skills in the evaluation questions.

The skill required in the questions varied in terms of the key idea considered and also, at times, depending on the group of teachers. In table 1 the number of groups is included that asked for a certain skill in relation to each key idea, as well as an example representative of the type of questions asked. In particular, it could be seen that:

- With respect to nutrition the most requested skills in the two groups is definition, while with respect to the systems involved the most requested skills was description.
- With respect to food and to the food/health relation, description is always the most requested skills in the Primary group. However, in the Secondary group the most requested skill is definition (in the case of food) and justification (in the case of food and health).

Key ideas/Associated skills		**Primary** N= 32	**Secondary** N= 22	**Examples of questions**
N. Human nutrition	**N-Ds.** Description of the process	10 31.3%	8 36.4%	• *"Complete…: Human beings need... the foods in… , that they use for…*
	N-Df. Definition of nutrition	**26** **81.3%**	11 50.0%	• *"What is nutrition?"*
	N-J. Justification of its function	12 37.5%	8 36.4%	• *Why do we say that nutrition is a vital function?*
S. Systems involved	**S-Ds.** Anatomical/ functional description	**31** **96.9%**	**19** **86.4 %**	• *Name the following organs and equipment in the illustrations* •
	S-Df. Definition of its function	1 3.1%	2 9.1%	• *What systems are involved… and what function does each one serve?*
	S-J. Justification of its function	--	4 18.2%	• *What do you think would happen of the circulation system didn't exist?*
A. Food	**A-Ds.** Description of types of food	**20** **62.5%**	8 36.4%	• *Classify the following foods in terms of their origin. Indicate which nutrients each food has.*
	A-Df Definition of the food/nutrient	16 50.0%	15 **68.2%**	• *What are foods? What are nutrients?*
	A-J. Justification of its function	1 3.1%	6 27.3%	• *What would happen if we didn't eat?*
D. Food/health	**D-Ds** Description of healthy diets	**19** **59.4%**	7 31.8%	*Detail what a healthy diet would be for you throughout a whole day.*
	D-Df Definition of healthy diet	**13** **40.6%**	**10** **45.5%**	• *What do you understand by healthy diet?*
	D-J Justification of its importance	10 31.3%	**18** **81.8%**	*Is it advisable toe at sweet foods every day? Indicate whether or not it is correct by justifying your answer.*

Ds, description; Df, definition; J, Justification

Table 1. Percentage of groups that require different skills in evaluation questions, associated to each key idea

The Trainee teachers do not always identify which skill is required from the questions asked (Figure 2). Less than 60% of the groups from both Primary and Secondary that asked for a description, in terms of the various key ideas, recognize this request. However, the percentage is higher in the case of the justifications and even more so in definitions.

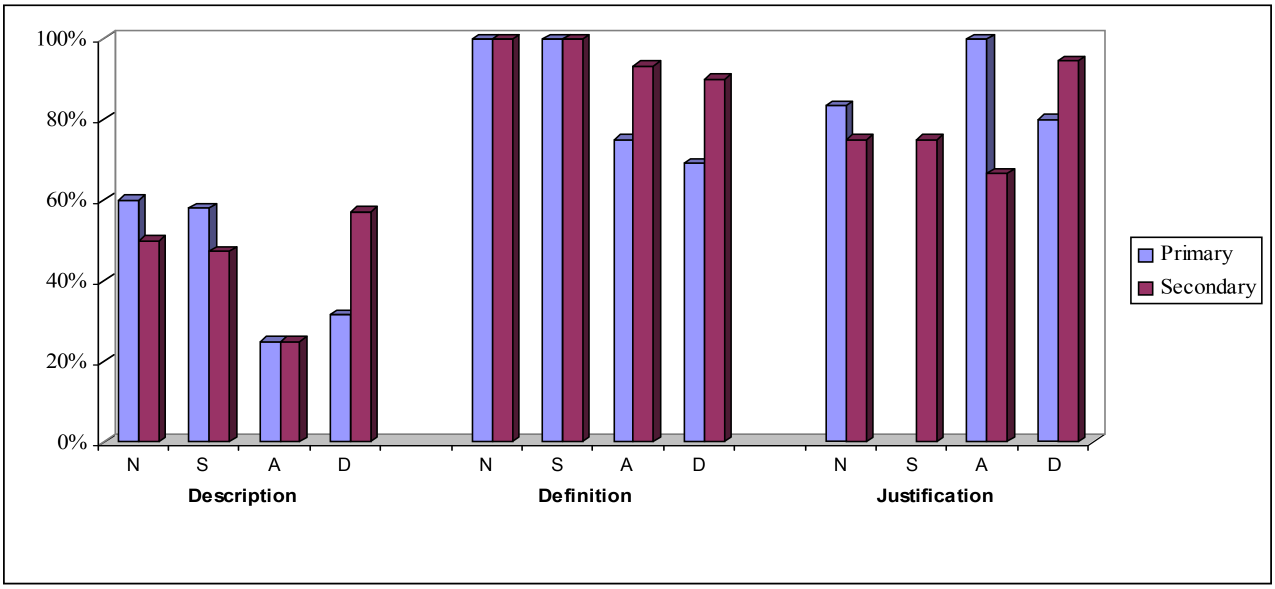

Figure 2. Percentage of groups that identify the skills requested in the evaluation questions.

Now let us look further into the type of skill which the teachers identify in the descriptive questions asked. The majority of the groups which did not recognize that they are asking for a description believe that they are asking for a justification (Figure 3).

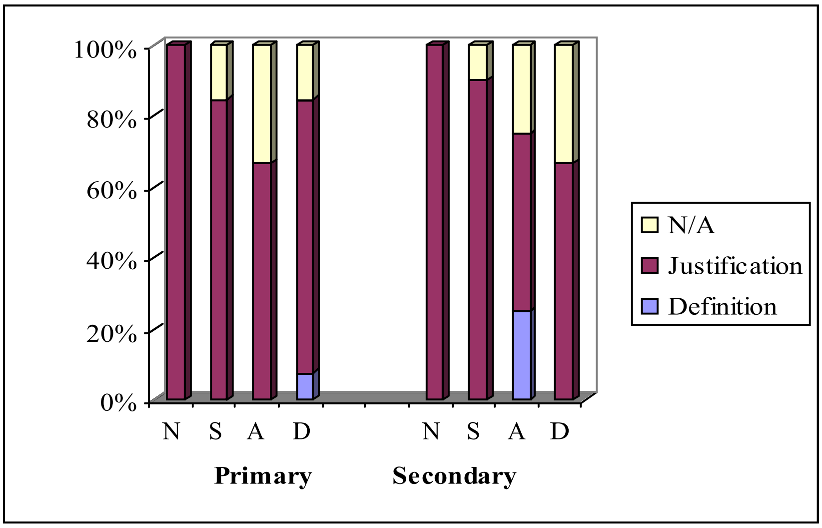

Figure 3. Percentage of groups which identify different skills in the descriptions from the descriptive questions asked.

CONCLUSIONS

The trainee teachers give more importance to the description and definition than to the justification, especially in Primary education.

- A connection between the type of skill requested and the key idea considered can be seen, although this connection does not always coincide in the two groups.
- The teachers are not always conscious of the skill they request in the questions.

The conclusions show an area where more attention should be paid in teacher training, which should focus more on the importance of teaching how to give justifications, as they are essential for the understanding of the subject of human nutrition. This is relevant in Secondary teacher training, which should introduce justification, not only to aspects related to food and health, but also to the actual concept of nutrition and the functioning of the organs and systems involved. It is also relevant in Primary teacher training, as at an accessible level, children can understand what is happening in their bodies and/or justify why a good diet influences health.

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ASSESSING PROSPECTIVE TEACHERS' DIAGNOSTIC COMPETENCE

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Abstract: Among the competences outlined to be relevant for pre- and in-service teachers, assessment and diagnosis are frequently mentioned. Teachers need to be able to identify pupils' conceptions as well as their learning outcomes and have to monitor pupils' learning processes in order to design instruction accordingly. Even though diagnosis plays an important role in teacher profession, it is rarely explicitly addressed in educational research. Here, we describe four different types of diagnosis: diagnosis of a status, of a solution process, of progression in status/solution process, and of learning processes. These different types can be assigned to the notion of summative and formative assessment, but at the same time help to describe more precisely the different diagnostic activities teachers should apply. In our project, they also serve as theoretical framework for the methods we use to investigate teachers' learning. Two cohorts of prospective teachers are monitored during their university education. Using questionnaires and video, we assess their prior knowledge and their progress for both content knowledge and those aspects of pedagogical content knowledge and pedagogical knowledge which are related to diagnosis. The main focus of this paper lies on our theoretical considerations and the methodological challenges we face. Some results will also be presented.

Keywords: Diagnosis, diagnostic competence, pre-service teacher education, assessment

During the last couple of years, an increasing number of research projects have addressed teacher profession and teacher knowledge (for an overview see e.g., Abell, 2007). Shulman's distinction between subject matter knowledge/content knowledge (CK), pedagogical content knowledge (PCK), and pedagogical knowledge (PK) (e.g., Shulman, 1987) is often used in these projects to describe teachers' professional knowledge. Within these competences, teachers' abilities to assess pupils' content specific knowledge and their learning processes are highly valued. Such a focus on pupils is a main prerequisite to design instruction with appropriate learning demand, for instance, by taking pupils' prior conceptions into account. Even though knowledge about pupils' learning and methods by which this knowledge can be achieved are considered to be important aspects of professional competences, they are typically not addressed in detail in recent research projects. In particular, diagnosis is not very well theoretically framed, neither is diagnostic competence. Therefore, the main aims of our project are to establish a distinction between different types of diagnosis in order to 1) describe corresponding teacher activities and their outcomes and 2) situate our own assessments of teacher learning. Furthermore, the distinctions are embedded into a model of (prospective) teachers' diagnostic competence which serves as a heuristic to analyze the expected progress prospective teachers make during their university education.

DIFFERENT TYPES OF DIAGNOSIS

Generally, when we refer to the notion of diagnosis we refer to all kinds of assessment which try to get an idea of a learner's current knowledge, her/his abilities, changes in knowledge and abilities, and the learning that takes place. Diagnosis is strongly related to the aim of improving education for the learner or a group of learners assessed. We stress the importance of diagnosis as a means to improve understanding of learning and effective instruction. With questionnaires such as the Force Concept Inventory (FCI, Halloun, Hake & Mosca, 1995, see item in Figure 1), researchers intend to assess conceptions pupils (and sometimes also teachers) possess at a specific point in time. For example, for the item presented in Figure 1 prospective teachers tend to choose solution D (incorrect) rather than solution C (correct). **Assessing the knowledge and abilities that learners have at a specific point in time is what we refer to as "diagnosis of a status."**

A woman exerts a constant horizontal force on a large box. As a result, the box moves across a horizontal floor at a constant speed "v_0".
The constant horizontal force applied by the woman:

(A) has the same magnitude as the weight of the box.
(B) is greater than the weight of the box.
(C) has the same magnitude as the total force which resists the motion of the box.
(D) is greater than the total force which resists the motion of the box.
(E) is greater than either the weight of the box or the total force which resists its motion.

Figure 1. Example of an item to assess student misconception in Mechanics (FCI, Halloun, Hake & Mosca, 1995)

T2: […] **Well, I would say greater**, isn't it?
T1: Greater? […]
T2: But, no, wait. Hold it. **Same magnitude, because the box is moving already. We don't have to accelerate it.** It says "the box moves at a constant speed", that is, it moves. (indicates movement on the table) **And we are right in the middle of the movement. Therefore, they have to have the same magnitude.**
T1: Well, you mean, it's the same as the example with the lorry, only different?
T2: I don't know, I don't think so. **But, if they had the same magnitude, then they would stand still, wouldn't they?** (indicates stopping with his hands)

Figure 2. Two prospective teachers (T1 and T2) discuss the task presented in Figure 1 (bold: indicates the solutions chosen by T2, switching from D to C and back to D).

In order to diagnose a status, researchers and teachers typically use a learner's assessment product such as a multiple choice answer, a short answer given to a question, a drawing, and so on. However, these products often do not give much information on how a learner has conceptualized the task. For example, they do not take into account the ideas that came into her/his mind and the operations s/he performed while solving the task, the cross-references the learner makes to examples s/he has worked on previously, and so on. Monitoring these processes in which a learner (or a group of learners) come(s) to a specific solution (the product) will give more insights into the opportunities and challenges a learner faces. In Figure 2, the dialogue of two prospective teachers who try to solve the task given in Figure 1 is presented. Even though these prospective teachers ticked "D" as an answer, prospective teacher 2 (T2) is able to develop a correct interpretation as well. Thus, instruction does not need to establish the idea on Newton's Third Law but has probably to use more examples in order to practice identifying how to apply this law. **Assessing a learner's performance (verbal and non-verbal, for instance tackling experimental equipment) while s/he tries to solve a specific task is what we call "diagnosis of a solution process."** Both, diagnosis of a status or diagnosis of a solution process, are directed towards assessing the knowledge and abilities a learner holds at a specific point in time. They play a dominant role in research and teaching.

In order to be able to say something about progress, assessment (either of the status or the solution process) has to be repeated after a specific span of time, using similar tasks than for the first assessment. It is typically assumed that learning has happened between these two different points of assessment, thus, a progress should have occurred. **The kind of assessment applied to diagnose changes in a status or a process is what we call "diagnosis of progression".** Diagnosis of progression is more common to research than to education in school, as teachers typically do not formally assess pupils' prior knowledge and its changes as a result of instruction.

Assessing the progression that has taken place does not offer insights into how this change has come about. Which intermediate steps were necessary? How was instruction utilized (which was helpful and in what way)? If a learner, for instance, is not able to pick the correct answer because s/he has not yet any idea of Newton's Third Law (see Fig. 1), how is an appropriate idea that leads to picking answer C developed? Assessing how learning occurs (not "just" changes or progression over a longer period of time) requires some sort of continuous measurement in order to trace how new or existing ideas are developed**. Assessing in which way new knowledge and abilities are established is what we call "diagnosis of learning processes"**. This assessment would monitor, for instance, *all* instances in which learners discuss Newton's Third Law during instruction (and, if possible, while doing homework on that issue). We know that this kind of diagnosis is rather complex, can be performed by teachers only informally and is rare in current research on pupil or teacher learning. However, even if it is rare, it is different from the other three types of diagnosis and the here presented distinction can also help to identify the projects which focus on this kind of assessment.

DIAGNOSTIC COMPETENCE

In our research project we assume that teachers are able to distinguish the four types of diagnosis described above and are able to apply them purposefully in order to evaluate and improve their instruction. Also, teachers should know about typical results, e.g., gained from research, and how these results are framed theoretically in order to develop appropriate instruction. Prospective teachers should, therefore, for instance, be able to…

…assess pupils' knowledge, abilities, interests, and self-concepts with appropriate tests or questionnaires. [diagnosis of a status]

…evaluate whether pupils work on tasks as expected/what kind of learning difficulties pupils encounter. [diagnosis of a process]

…explain levels which can be used to assess subject-matter and/or content-specific progression. [diagnosis of progression]

…monitor how a series of learning tasks help pupils to establish new competences. [diagnosis of learning processes]

…distinguish between different types of diagnosis and illustrate their distinctions with appropriate examples. [all types of diagnosis]

The standards are grouped together in a model of diagnostic competence (e.g. v. Aufschnaiter et al., 2009). All standards associated with diagnostic competence can be related to current ideas on PCK and PK. In addition, the model assumes that CK has an impact on the development of diagnostic competence, thus, it includes some standards on subject-matter competence which can be related to the idea of CK. Furthermore, the model includes some standards which refer to the outcomes of diagnostic competence in terms of using knowledge and abilities associated with diagnosis for the development of instruction. In addition to these three areas (diagnostic competence, subject-matter competence, and competence to develop instruction based on procedures and results of diagnosis) we assume that (prospective) teachers' attitudes/beliefs, motivation, self-regulation, and cognitive abilities have an influence on the development of diagnostic competence. It has to be noted that, so far, the model serves as a heuristic to explore teacher learning. We are not yet planning to evaluate the model, but are well aware that this needs to be the next step in our research plan.

SAMPLE

In our project two cohorts of prospective teachers (at the beginning typically about 20 years old) are monitored throughout their university education over a period of four years (10/2008-09/2012). Cohort 1 has started in 2008, cohort 2 in 2009. In Germany, all prospective teachers study two different subjects which they will then later teach at school. Here, in each cohort all participants study either two sciences as subjects or a science subject and mathematics. These prospective teachers are trained for middle and also partly for upper secondary level. Due to organizational aspects, we mainly gather data from prospective teachers who chose biology and physics as their future school subjects. Therefore, in this paper we concentrate on these two sciences and present how we explored different types of diagnosis, using both, instruments already established in other groups as well as instruments that have been developed by ourselves during the course of this study. "Diagnosis" occurs in two different ways in our project: (a) It is used to describe and promote teachers' diagnostic competence and (b) it is used as research method, in that we describe our own research in terms of diagnosis of a status or a process or progression or learning processes. In the following to sections we present how we use the different types of diagnosis in our research (b).

METHODS AND RESULTS 1: DIAGNOSIS OF STATUS AND CHANGES IN STATUS

Current research on teacher education typically uses paper-pencil-tests to assess teachers' current knowledge and (sometimes) its progress before and after specific instruction (more often differently experienced groups of teachers are compared). For instance, components of CK are assessed with TIMSS-items; in physics, instruments such as the FCI (Halloun, Hake & Mosca, 1995) or the test on electricity (Shipstone et al., 1988) are used to design specific instruments for teacher education (e.g., Olszewski, 2010; Riese, 2009). For PCK- and PK-components, there is an ongoing research aiming to establish reliable and valid items (e.g., Jüttner & Neuhaus, 2011, Olszewski, 2010; Riese, 2009).

In the past 3 years we have been using some of these instruments for our own diagnosis of prospective teachers' status with respect to their subject-matter competence and those components of PCK that are associated with diagnosis. These instruments are applied roughly once a year, starting with a large number of CK-related items and progressing slowly to PCK-items with increasing complexity. We use anchor items in all questionnaires in order to determine progress. For physics, the results (N=68) indicate, that at the beginning of their university education the prospective teachers hold similar misconceptions like pupils do. Our results also indicate that subject-matter knowledge in one area (here: mechanics) is not a good predictor for knowledge in another area (here: electricity), especially when scores in mechanics are low. We have a significant increase in the prospective teachers' knowledge after one year but cannot say what causes this increase as we were not able to diagnose the prospective teachers' learning processes throughout all related subject-matter courses. So far, our results on subject-matter knowledge explain (only) about 25% of variance in diagnostic competence. Interestingly, we were able to identify relatively high scores in subject-matter knowledge of individual prospective teachers while at the same time these participants score low in their diagnostic competence.

When searching for already established instruments for measuring diagnostic competence it turned out that most show at least two restrictions. First, almost all available instruments were designed for math or physics teachers. Instruments especially made for biology teachers seem to be rare (see Jüttner and Neuhaus (2011) for an example). Furthermore, all instruments mainly focus on knowledge *of* science (or PCK with reference to science content), but not to knowledge *about* science (and PCK including aspects of diagnosing, for instance, how well pupils perform an experiment or what their knowledge of scientific inquiry is) even though the latter has recently been stressed as an important goal of teacher education (e.g., AAAS, 2009; Millar & Osborne, 1998). Here, our aim was to establish a new instrument to diagnose the status of prospective teachers' abilities to assess pupils' scientific inquiry competence.

In our instrument we use the theoretically assumed and empirically proven four subskills of scientific inquiry, (see Möller & Mayer, 2009 for details; the rather practical skill "conducting an experiment" was not part of this study): (1) formulating scientific questions, (2) generating hypotheses, (3) planning an investigation, and (4) interpretation of obtained data. Pupils were given test items with a description of a specific biological setting (e.g., the number of wood beetles and woodpeckers in a forest) and were then asked either to formulate a question, to develop a hypothesis, to plan an investigation, or to interpret given data (see Möller & Mayer, 2009 for details). The pupils' answers were assigned to five *a priory* defined different performance levels in each subskill (questions, hypotheses, investigation, interpretation, see example in Table 1 for the subskill "generating hypotheses").

Table 1. *Description of competence levels for the subskill "generating hypotheses" (Mayer & Möller, 2009); level 5 is not used in our diagnostic instrument*

Competence Level	Description
1	Generate simple testable hypotheses without explanation
2	Generate hypotheses based on analogies from everyday life
3	Generate hypotheses based on biological concept knowledge
4	Generate hypotheses that are generalizable and/or quantifiable
5	Discuss alternative hypotheses

For our instrument in pre-service teacher education, the prospective teachers were given the test items that were handed out to the pupils, the pupils' original answers as well as the descriptions of the four levels (see Table 1). The prospective teachers were then asked to assign the pupils' answers to the appropriate performance levels. Thus, we used diagnosis of a status in order to diagnose the prospective teachers' ability to diagnose a status from learners' products (their answers). In total, 95 prospective teachers participated, each of them completing two different test-booklets. A test booklet focused on one subskill of scientific inquiry (for instance, on the formulation of an appropriate question) and contained in total 16 pupils' answers for different settings. Thus, each prospective teacher roughly assigned levels to 32 pupils' answers, of which 16 referred to one and 16 to another subskill of scientific inquiry.

Results demonstrate that prospective teachers were better in assigning pupils´ answers on lower levels than higher levels (compared to the assignments of a group of researchers). Furthermore, a more in depth analysis of the results shows that assigning levels to pupils' test answers in the subskill "interpretation of the obtained data" was significantly easier for the prospective teachers than in the subskill "planning an investigation". In order to get more information about the reasons for these results and to evaluate the validity of our diagnostic instrument we adjoined a diagnosis of the solution process in which the prospective teachers make their decisions on which performance level to choose. This was conducted by videoing them while working on the diagnostic test and talking about the correct assignment. First results regarding this indicate that the prospective teachers often have difficulties with the more complex and more detailed criteria of the high levels. Investigating the correlation between CK and the measured diagnostic competence of the prospective teachers, we found a significant but low correlation ($r=0,34$; $P=0,001$) between their knowledge of scientific inquiry (assessed with an instrument based on multiple choice tasks which are referred to the above mentioned four subskills of inquiry) and their ability to assign performance levels to the pupils´ answers correctly.

METHODS AND RESULTS 2: DIAGNOSIS OF SOLUTION PROCESSES AND CHANGES IN SOLUTION PROCESSES

In order to get a more detailed insight into how prospective teachers make use of their diagnostic competence they have developed so far and in order to check how their solution processes relate to their answers in the written test instrument, we videotaped groups of the participating prospective teachers while assigning the pupils' test answers to the appropriate competence levels. In physics, the videos are taken roughly two times a year, four settings in total, each centered around a task, and vary in length between 40-70 minutes. We assess the prospective teachers in groups of four, four groups per cohort. Task one and task three ask the prospective teachers to discuss pupils' answers on work sheets and to analyze a piece of video together with a transcript which documents pupils' group work. Thus, task one and task three focus on learning issues. In task two and task four the prospective teachers have to plan a lesson sequence and have to analyze a description of a lesson sequence. Thus, these two tasks focus on teaching issues. All prospective teachers who were documented with video have given their consent to be filmed. We asked those prospective teachers to be filmed who have participated in (almost) all written tests/questionnaires carried out so far. With the videos, we want to identify, for instance, whether the prospective teachers use empirical results or theoretical assumptions to justify their interpretations or decisions. We also aim to identify the amount of time our participants spend, for instance, on working on the tasks, clarifying subject-matter aspects, or talking about issues which are not related with the task ("off-task activities").

The main challenge we currently face with the videos is to set-up a coding scheme and manual that is in accordance with our model of diagnostic competence but is also able to describe the processes we observe – which does not always necessarily match the model's descriptions. All codes are applied on a 10-second-interval basis, each participant is coded individually. Coding always starts by identifying the focus of the activity. Here, we distinguish, for instance, between a focus on learning, a focus on teaching, or a focus on the clarification of the content of the task. The subsequent category "behavior" assesses whether a prospective teacher describes or plans pupil and/or teacher behavior. The category "teaching-learning-setting" is chosen whenever a prospective teacher elaborates on how the content of a lesson is ordered, what the characteristics of a learning task are, or which methods/media are chosen or have to be chosen, respectively. Finally, the system includes two categories which describe how the prospective teachers justify their interpretations or their decisions. These categories are important in our research as they offer, for instance, an insight into how often the prospective teachers base their interpretations on results and methods of diagnosis.

First and very preliminary results, so far only with a reduced data-set, indicate that the system can be applied successfully to the different groups and tasks we have. Roughly 45% of the time spent on the tasks is taken for reading and writing, about 35% of the time is used for discussing learning or teaching issues, and about 13% of the time is spent for clarification. To our own surprise, we can only identify about 1% of off-task activities (e.g., talking about their private plans for the weekend). Another surprising preliminary result is that our prospective teachers only spent about 3% of the total time justifying their interpretations or their decisions. Furthermore, the prospective teachers did only focus on pupils (in both their interpretations and their decisions) when the pupils were "present" in the tasks. That is, only if pupils' answers were to be discussed or an excerpt from a lesson includes descriptions of pupils' utterances and activities our prospective teachers included a pupil-oriented focus in their discussions. This is particularly interesting as a pupil focus was almost completely absent from the prospective teachers activities while planning a teaching sequence. We do not yet wish to give any possible interpretation for these results as we have not investigated all of our videos and have not yet related these results to outcomes of our diagnosis of status.

As the videos are taken throughout the whole university education we expect detailed information on how diagnostic competence progresses from comparing the processes of individual prospective teachers and their possible change and/or improvement between the different videos. However, we are not able to diagnose the prospective teachers' learning processes as we cannot monitor them continuously in those lectures which are related to the learning we want to assess.

CONCLUSIONS AND IMPLICATIONS

With its emphasis on diagnostic competence the project approaches important issues in teacher education with a novel focus. The distinctions made for diagnosis, the model for diagnostic competence and the instruments explored can help to broaden our idea of research on teacher education and may offer examples on how to assess teachers' learning in more depth.

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TRAINING ELEMENTARY SCHOOL TEACHERS FOR THE USE OF SCIENCE MUSEUM FIELD TRIPS IN EARLY EDUCATION

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Abstract: Science centers provide a good opportunity to work with science material out-of-school and should be included as a teaching-learning tool in science teacher education. This study analysizes the implementation of a teaching curriculum where elementary school teachers learn to integrate the teachings of scientific content using a field trip to a science museum. The results obtained show marked improvement in the experimental students' conceptions, so we think that the explicit integration of informal resources into the classroom curriculum offers significant improvements to the teaching-learning process that must be worked into the initial teacher training at all educational levels.

Keywords: initial teacher training, science museum, non formal education.

BACKGROUND AND PURPOSE

The education reforms put into place in the late 80s aimed to emphasize the way in which sciences were treated in order to improve the science teaching itself. The education standards of various countries stress the importance of introducing science as a creative process that develops theories and concepts to come up with tentative solutions to problems presented by both scientists and society. (National Science Education Standard, 1996; Spanish Science Standards, 2007).

Our interests center around the opportunity science museums provide for training elementary school teachers being locations with great potential for applying teaching materials to real world problems, both through experimental activities as well as expert reporting that delves deeper into scientific knowledge and its connection to society. This promotes a reflective practice in the field of science which the aim of complement formal education with informal contexts (Dierking et al., 2004).

Accordingly, studies conducted in the last few years on what is learned during field trips to science centers emphasize the importance of planning so that the perspective gained is effectual and lasting (Henriksen and Jorde, 2001). This planning should be explicitly emphasized within the school curriculum in such a way that activities are planned leading up to the field trip, during the visit itself, and then again upon return, to reinforce the experiences had while there (Anderson et al., 2003).

In prior studies, we have been able to substantiate that Elementary and Secondary School teachers in the Basque Country (Spain) does not adequately plan these visits and that their concept around the visit falls short of the research's recomendations. In other words, they view these field trips as a "free time activity", a type of extracurricular activity, that is, recreational and interesting in nature but not as a learning tool for their students (Guisasola and Morentin, 2010).

The science centers provide a good opportunity to work with science material out-of-school and should be included as a teaching-learning tool in science teacher education but teachers, in general, do not have the necessary strategies to prepare the visit properly, because at least in Spain, very few initial teacher training courses for primary and secondary implicate future teachers in learning experiences outside the classroom.

The study covered in this presentation analysizes the implementation of a teaching curriculum where elementary school teachers learn to integrate the teachings of scientific content using field trips to science museums. In particular, the study responds to the following questions of the investigation:

1) How do we design and implement a teaching curriculum for elementary school teachers which integrates science museum field trips with classroom education?
2) What do future teachers learn about organizing and developing science museum and center field trips?

RATIONALE

Scientific literacy has become one of the primary objectives for teaching science (Rocard et al., 2007), but different studies show that regardless of this new direction at different education levels in science literacy, both progressive and comprehensive implementation remains traditional and insignificant (Hofstein and Rosenfeld, 1996). In response primarily to the lack of adequate preparation for teaching science among Pre-service Elementary Teachers, Mellado (1998) points out the lack of understanding science as an activity immersed in a socio-cultural context, influenced by social and cultural values with its own process and characteristics.

These recommendations, together with other suggestions from the investigation on science museums (Falk and Dierking, 2000), make up the conceptual framework of this study and our own investigation centers on the need for the training of elementary school teachers to include knowing how to utilize the teaching and learning tools as offered by science museums and centers.

METHODS

In the University of the Basque Country Programme for Elementary School Teachers, a small curriculum of sciences is worked out for the second of the four years that make up the Degree. For this investigation, we have included within the training program a new teaching unit on the role that forces develop under daily situations but this educational unit involves also the preparation and visit to the *Eureka Science Museum* in relation to the topic of forces. We know that we cannot "teach" future teachers how to prepare a visit to the museum, in an abstract way, and so we decided to include that visit to the museum within the school curriculum as a part of scientific training for future teachers, so that in their future jobs they might have the necessary didactic strategies to design a visit to a museum helping students to really make the most of it.

The *Eureka SM of San Sebastian* is the unique science museum found in the Basque Country (see http://www.eurekamuseoa.es). It was inaugurated in 2001 as KutxaEspacio S.M. but it changed its name four months ago.

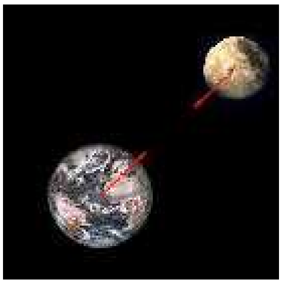
The teaching unit design covers the recommendations made by the investigation for science museum field trips, keeping in mind such aspects as integrating the visit to the science museum into the unit, performing activities prior to the visit, creating activities to perform during and after the visit, strategically working with subjects fitting the context of the museum and taking into account the ways of learning in out-of-school contexts.

So, the first result of this work is the actual educational unit or teaching material entitled "Forces in action", designed with the aim of working on the topic of forces and its didactics (topic included in the curriculum for our subject) whilst putting into practice some of the strategies required for preparing a visit to the science museum.

We chose the topic of "forces" due to the fact that *force* is one of the contents present in the Primary Education curriculum whose conception, whilst not simple, must be worked on from this stage. In addition, we know that one of the topics in the Primary curriculum that is most represented in science museums in general and in the Eureka museum in San Sebastian in particular is that of "forces and machines" with a large number of modules spread over several rooms. Finally, to finish justifying the choice of topic, we might say that "force" is one of the most researched concepts from the point of view of alternative ideas, and the bibliography tells us that poor results found in the students' conceptions could be improved by working on the force model from primary education.

Among the different activities making up the teaching sequence, some take place before the visit, others during the visit and others afterwards. We will give some examples of activities:

Example 1 (Activity 18.) In groups, answer these questions:



Is there a force of attraction between two apples?

What about between the Earth and the Moon?

Explain your answers.

This is an easy activity for before the visit, aiming to work on gravitational attraction. Students have to work in small groups, and after that there will be a brainstorming where they have to explain their answers.

Example 2 (Activity 26.) In groups,

Have you ever seen a bed of nails?

Imagine someone lying down on a bed of over 7000 nails. In the museum, anyone who wants to try can lie down and check the effect of the nails.

What are the existing forces?

Why do we feel no pain?

Will it depend on our weight?

This activity refers to the 'bed of nails', it is also an activity to be done beforehand and it can be used to relate the concepts of force and weight with pressure. The photo shows the exhibition that students will see in the SC, and they have to answer those questions previous to the visit and after it; then they will compare their own answers and they will understand the concept they had learned in the museum.

The last example is an activity for after the visit where students have to reproduce an experiment seen in the museum.

Example 3 (Activity 29.) **Eureka!**

You have to carry out a similar experiment to what we saw in the SC (Archimedes Principle). This involves calculating the masses and the weights of the different objects in both the air and the water but you have to design the experiment yourself (in groups).

1. **Design and write down the experiment (steps and materials)**
2. **Carry out the experiment, noting down the data obtained**
3. **Explain what happened, draw conclusions and relate it to what was done in the SC**

In this activity students have to design the experiment, they don't have the "recipe", and they have to remember what they made in the museum and make their own practice; then they have to explain their own conclusion to their mates.

The all teaching unit was worked with a group of second year teaching students during the regular teaching year, 6 sessions of 2 hours (field trip included). After that and to evaluate the possible changes in the students' conception of science museum field trips used as a learning tool, a survey of 5 open-ended questions pre-test and post-test was designed for this group; once all questions were collected, the answers were analyzed and categorized after encoding the ideas, noting common patterns and grouping principle tendencies (Cohen et al., 2007). Along these lines, the frequencies of each category were calculated to check the differences between pre- and post-test, using the Hake index (1998) to calculate gains.

RESULTS

The results obtained show marked improvement as significant changes were reached in the experimental students' conceptions. Some results tables are shown.

What features should a SC visit have to be effective?	PRETEST N= 38	POSTEST N= 36
Correct answers: Visit with activities before and after/ related to classroom topics	**4 (10.5%)**	**13 (36%)**
Incomplete answers: It should be useful for learning, with complementary activities (workshops, demonstrations…)	**8 (21%)**	**3 (8.3%)**
Alternative answers: Possibility of experimenting, practice, guided…	**26 (68%)**	**18 (50%)**
Unclassified answers or Don't know/No answer	**--**	**2 (5.5%)**

We asked our students about the characteristics that a visit should have to be effective and the correct answers increased from 10% to 36% after working on the DU; this positive result is ratified by the drop in the percentage of alternative answers (from 68% to 50%) referring uniquely to the practical and experimental aspects of the visit, as well as the drop in the percentage of incomplete answers.

Visits to SC are useful when…	PRETEST N=38	POSTEST N=36
Correct answers: They are used for learning related to the curriculum/ Teachers prepare them previously in the classroom	**3 (7.9%)**	**11 (30.5%)**
Incomplete answers: They are used to check what was studied in class / To learn more (without specifying)	**20 (52.6%)**	**13 (36.1%)**
Alternative answers: They are used to arouse interest in science/ They are fun, entertaining, recreational	**12 (31.6%)**	**11 (30.5%)**
Unclassified answers or Don't know/No answer	**3 (7.9%)**	**1 (2.9%)**

In this second table, results are about the usefulness of these visits. As in the pre-test, this last percentage is so small (7.9%), we might conclude that the students' initial conception has evolved in a greater proportion towards a more complete conception of the visit; the percentage of correct answers is about 30% after classes. The drop in the percentage of incomplete answers also ratifies this improvement, but it can be seen that is difficult to modify "common sense" conceptions (alternative) that only include some recreational aspects of these visits (from 31.6% in the pre-test to 30.5% in the post-test); this result fits whit others shown in previous researches (DeWitt & Osborne, 2007; Olson et al., 2001).

After the implementation of the teaching unit, these students rated the science museum field trips as very useful not only for their value as an experimental work experience, but for their contribution to the contextualization of science in the school's curriculum. Their initial conception has been changed and they have reflected about the work of the teacher that has to prepare the visit properly for their students to be effective.

CONCLUSIONS AND IMPLICATIONS

Applying the teaching unit to second year Elementary Teachers students has incited an evolution in the students' conception from a common sense idea in which "the field trip serves as a way to have a good time and motivate the students" to one we had aimed for, "a field trip is fun, but you can learn adequate and accurate information if you prepare for it". In their responses students demonstrate that they learned to use certain tools recommended by the research to prepare school science center field trips, although it is difficult to change some common sense conceptions, as we have said.

We are aware that this experiment has been carried out within a very specific context and conditions, but we think that it ratifies our proposal significantly. So we can conclude that:

- The visit to the science centre has to be included within the school curriculum to be effective.

- If future teachers have experienced how to prepare visits to the museum in their initial training, we think that it will be easier for them to put this into practice in their professional future.

Although we know that other variables exist, we think that the explicit integration of informal resources into the classroom curriculum offers significant improvements to the teaching-learning process that must be worked into the initial teacher training at all educational levels.

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FUTURE TEACHERS' VIEWS ON COMMUNITY PROJECTS AS LEARNING ENVIRONMENTS FOR SCIENCE EDUCATION

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Abstract: This paper presents some findings of the action-research process that accompany the project *Girona, seed city for Science.* It focuses on future teachers' views on community projects as learning environments for science education and sustainability. It also identifies implications for pre-service teacher education reform. The research seeks to explore the opinion and perceptions of the future teachers as participants in the community project for science education. The science education community project *Girona, seed city for science* began as part of the European Project *Pollen, Seed cities for science: a community approach for a Sustainable Growth of science education in Europe.*

Keywords: Pre-service teacher education, community project, science education, learning environments, student involvement.

BACKGROUND, FRAMEWORK, AND PURPOSE

This text focuses on future teachers' views on community projects as learning environments for science education and sustainability and it identifies implications for pre-service teacher education reform.

The purpose of this paper is to present some findings of the action-research process that accompany the development of the project *Girona, seed city for Science*. The research seeks to explore the opinion and perceptions of the future teachers as participants in the community project for science education. The science education community project *Girona, seed city for science* began as part of the European Project *Pollen, Seed cities for science: a community approach for a Sustainable Growth of science education in Europe.* The Rocard Report (2007) featured it as one of best experiences in science education in Europe.

Pollen is a European project for research and development funded by the Sixth Framework Programme of the European Commission which took place between 2006 and 2009. Twelve countries participated as partners and during the three year duration of the financed project twelve initiatives were developed simultaneously: a seed city for science in each country (the Spanish seed city was Girona). Once the European funding ended, the local partners in Girona decided to continue it with local resources. The community project aims to stimulate and support science teaching and learning in primary schools (children aged 3 to 12 years) by promoting hands-on and inquiry-based science education for sustainability. The project involves local authorities, the faculties of education and sciences and also present and future teachers in a sustainable framework for science education through a child-centred approach starting in school and extending to the whole city.

The main activities of the community project are initial and in-service teacher education seminars and community events such as *the Science Fair for Little Big Scientists*, the *Researchers' Night* or the *Bio-Market day*. In addition, the project offers advice and guidance to the participant schools and teachers on a request basis.

The future teachers are university students enrolled in teaching degrees (early childhood teacher studies and primary education teacher studies), and they can participate in the project basically in two different and complementary ways. On one hand, from 2008 until nowadays the first year's students design, implement and evaluate a science workshop at the Science Fair. This is part of their compulsory practical work of a science teaching course. On the other hand, they can be involved in the project as volunteers when they are in the last years of their degree and become part of the organizing committee of community events and support other activities such as training sessions or schools visits.

RATIONALE

An important part of the research being conducted is aimed at developing a proposal to improve the initial teachers' education, above all related to the pre-service teacher education reform. Higher Education Curriculums have recently changed in Europe as a response to the new European Higher Education Area. Besides, new educational and political trends are forcing curriculum changes all over Europe and other parts of the world (Jenkins 2009). The Spanish and Catalan curriculums – for all levels and stages of education, from kindergarten to University- have shift from a conceptual-content centred point of view to a competency-based approach. A competency is determined by the mobilisation of a combination of cognitive abilities and practical skills which are interrelated: knowledge (including tacit knowledge), motivation, values, emotions and other social, behavioural components which may be mobilised for effective action (OECD, 2002).

Teacher competences are then, by definition, developed, shown and demonstrated in action. Our hypothesis is that community projects can be used as real context learning environments for pre-service teachers while the project itself benefits from the participation of university students. There are some projects and researches that have tackled this new curriculum orientation in the field of teacher education and sustainability such as CSCT (Sleurs 2008) but more research is needed in order to better understand the processes involved and their implications in the organization and implementation of the teaching and learning environments and activities.

The purpose of this research is to gain knowledge concerning the process of student involvement, specially their own perceptions and vision of their participation in order to improve the project itself and take advantage of it as a powerful learning environment for initial teachers' education.

The research seeks to explore the opinion and perceptions of the future teachers **as participants** in the community project for science education, in order to answer the following research questions:

- What learning opportunities are created through the community project?
- What can the University do to support IBSE –ES oriented- in schools while taking advantage of the process as a powerful learning environment?
- What changes should we introduce in pre-service teachers education to improve the situation?

METHODS

The research aims to track systematic formative evaluation of the implementation process and project development Girona, seed city for science. We share the vision of Vidal and Mateu (1997) according to which "evaluative research is a set of processes for obtaining and analyzing information to make judgments about the object, phenomenon or process under investigation as part of decision-making process itself".

This is an evaluative research with a clear focus on action research approach. As Noffke (1997) stated it may help us -researchers and practitioners- learn to participate and change our practices so as to fit our personal settings by creating conditions for change at three levels - personal, professional and political. We share the idea that an appropriate form of professional development, such as Education for Sustainability in itself, must be contextualized, and respectful towards the creation of knowledge of those involved in the process.

During the process, three action-research cycles (Elliott, 2001 and Martí, 2002) have been completed, each one matching the academic courses 2008-09, 2009-10 and 2010-11. The analysed data used in this paper is from the two firsts cycles (from 2008 to 2010).

The methods used to obtain data are mainly qualitative. We used individual questionnaires (with open ended questions) and conducted few semi-structured interviews – 6 individually and 3 collectively- to pre-service teachers who were volunteers in 2008-2009 and 2009-2010 (32 students in total). Both the questionnaires and interviews had a double objective: on the first hand to identify opinions and perceptions about the tasks developed within the project; and on the second hand and also very important, to foster self-reflection and awareness about the learning process involved. There was also a documental review and participant and non participant observation to complement and contrast data.

The data has been analysed inductively, following Grounded theory, from a constructivist perspective (Charmaz, 2006). Initial findings were shown and discussed with the group of volunteers to add validity and to share the process and results with the participants.

RESULTS

According to students' own reflections, the volunteers raised three basic issues when deciding to participate. They all first highlighted their will to get involved in light of last year positive experience (compulsory participation). Secondly, they consider that the Science Fair event in particular and the community project in general offered a very good framework for introducing the participation of different groups and individuals in a local project related to their future profession and they wanted to be part of it. And finally, they pointed out their motivation to acquire more practical experience in contact with children. Only few students mentioned they volunteered because they liked science and/or science education.

The main reasons obtained to the question why did they decide to participate, were the following:

- A very positive experience in their first year (compulsory participation).
- To acquire more practical experience in contact with children.
- The project is interesting/useful and directly related to their future profession & the methodology engaging.
- They liked the people involved and the mood/atmosphere.

Only four students mentioned:

- Curiosity/interest in science.
- Lacking knowledge in science & science education.

<u>Students' quotes:</u>

- *"I believed that [the project] is really useful and it accomplish the goals that where set at the beginning. Besides, I agree with the methodology used and that's one of the most important things."*
- *"I decided to participate because it has been the first and only time that someone offers me a real opportunity to learn participating actively in such a project".*
- *"I decided to join because this opportunity was offered and it was a good way of being with children and that's something we rarely do here at the Faculty... And to learn having fun"*
- *"We have engaged each other talking about it, I think that as future teachers it's crucial we get interested in this kind of projects and get used to kids"*

<u>Professional, formative and personal gains</u>

When talking about what had they learnt in terms of "professional and formative gains", our participants mentioned the following ideas:

- Practical knowledge and skills development with children (design, prepare, test and assess activities)
- Learn to be a reflective practitioner

- Importance and usefulness of experimentation & inquiry (as something new/different/stimulating)
- Knowing how a community project works and its importance.
- New ideas, experiences and resources/materials
- Compare and contrast different ideas about science & education
- Meeting new people and getting to know others better.
- Scientific knowledge

And they were also asked to give their opinion about the possible “personal gains” obtained through this experience. They mentioned and talk about:

- Personal satisfaction: to be part of something big, important, useful and successful.
- Self-confidence.
- Personal contacts, bonding, high value of companionship and collective work.
- Lots of fun and good memories.
- New perspective about science (more open and positive).
- Realization & discovery of the power of engagement & motivation.

The team of volunteers gained autonomy and initiative as the academic year advanced and that generated a powerful sense of belonging to a learning community outside mainstream classes. That was identified as a new and highly positive experience for all the volunteers. The majority pointed out the value of dealing with their own interests and ideas while trying to fulfil the project goals. Some of them were puzzled by the fact of finding themselves asking for more “theory” as they found they were lacking of it when designing and implementing activities. They said they learnt a lot more when participating as volunteers rather than in ordinary courses. When asked about the reason why that might be, they answers were related to motivation, the sense of reality and meaningful learning. They recommend this experience to other students above all because it is one of the very few opportunities to practice their skills with real children and because they felt they were valued and trusted.

CONCLUSIONS AND IMPLICATIONS

From the results obtained during the action research process, we can say that the community project under study has great potential as a learning environment that complements the pre-service teacher education. This potential is based on one of their essential characteristics: it is a real project, adapted and developed based on the needs of the community participating. Each person or group involved contributes to the development process of the project and collective learning is being created together. Student teachers bring a huge dose of energy and enthusiasm and receive practical experience in a professional environment and very intense personal experiences.

During the 2008-2009 academic year ten volunteers participated and the following year were over thirty and they continue to increase. This trend is a clear indicator of the success of the initiative, and it is even more because students do not receive anything –

material or academically- in exchange for their participation, apart from the experience itself. Only a little tiny minority joined the project because they liked science, so that means we can take advantage of community projects to make science education more motivating to future teachers. This is a collective learning process and the only way to meet the challenges and opportunities is to keep learning together.

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A SURVEY OF PRESERVICE SCIENCE TEACHERS' CONCEPTIONS OF RESEARCH METHODS COURSE

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Abstract: Research skills are important in teaching profession as in any other professional field. Therefore, preservice science teachers should know what research methods are and how the knowledge related to research methods can be used in teaching profession. For that purpose a research methods course was included to preservice science teacher education curriculum in Turkey. The aim of the present study is to investigate preservice science teachers' conceptions of research methods course. A questionnaire composed of five open ended items was administered to purposively selected 31 preservice science teachers. Preservice science teachers indicated that the course can be useful mainly for academicians and researchers. Furthermore, only minority of the participants indicated the importance and usefulness of the course content for teaching profession.

Keywords: Research methods course, preservice science teachers, undergraduate course, science teacher education, research skills

INTRODUCTION

The field of education continuous to grow so rapidly with regard to both the knowledge it contains and the methodologies it employs (Fraenkel & Wallen, 2006). Therefore the ability to do research becomes extremely important for science teachers. In fact, research skills can be of great benefit to any professional person (Galpin, Hazelhurst, Mueller & Sanders, 2004). Since 2006 there is a scientific research methods course in preservice science teacher education curriculum in Turkey. Scientific research methods course is a course for 3rd year (5th semester) undergraduate students majoring in science education (YÖK, 2007). Therefore, preservice science teachers started to take this course since 2008. It involves 28 hours of lectures. The aims of the course are to provide students with the basic information needed to understand research process, to use the knowledge to design their own research investigation and permit students to read and understand the literature of educational research. Furthermore, this course aimed to give students opportunities to develop and practice a range of research related skills such as: critical thinking, critical reading, the ability to present a logical and coherent argument, presentation skills, looking events from a broader perspective etc. It is therefore important to present whether the course achieved its aims and whether students attach enough importance to the course and whether they are aware of its benefits while they are performing teaching profession. Therefore, the objective of this paper is to stimulate discussion on research methods education in preservice science teacher education program by obtaining students opinions about the course.

METHOD

A qualitative research method was chosen to enable the participants to express their own views and to use actual participant statements as data. Therefore, a questionnaire was constructed to determine pre service science teachers' views regarding Scientific Research Methods course by the researchers.

Sample

Purposive sampling methodology was followed. Students who have enrolled to Scientific Research Methods course were the participants of the study (N=31). The age of the students ranged from 20 to 22 yrs. Of the 31 students, 25 were female and 5 were male.

Data collection instrument

A questionnaire consisting of 5 open-ended questions was administered to each participant at the end of the course. The questions of the questionnaire are provided below.

- What is your opinion about having a research methods course in preservice science teacher education curriculum?
- Do you think that the information provided in the course will help you in daily life? Please explain.
- Considering the knowledge you have acquired in the course, will it be beneficial while performing the teaching profession?
- At most who do you think can benefit from information provided in the course?
- Where and for what purpose do you think the information provided in this course can be used at most?

Data analysis

The participants written responses were analyzed using content analysis. Through multiple passes over written responses a set of tentative categories were developed. Once these tentative categories were developed, researchers reread the participants written responses individually in order to code for specific instances of the categories. A joint reading followed to validate the categories gleaned from the first readings and to settle any disputes regarding coding. The inter ratter reliability for coding the participants' written responses to the open ended questions was 90.0%. Next, participants' representative responses that identify the categories and some outlying responses that carries significant and powerful message were selected.

RESULTS

The findings of the study are presented according to the themes revealed in participants' written responses to the open ended questions. Excerpts from their responses are included to clarify the thematic findings.

Question #1: What is your opinion about having a research methods course in preservice science teacher education curriculum? 74% of the participants indicated that there should be a course like that in the curriculum. However, the remaining participant considered the course as unnecessary. The views of the participants who considered the course as necessary mainly focused on enhancement of professional competence (f=6), necessity for academicians (f=6), planning and conducting a scientific research (f=6), and scientific thinking in solving a problem (f=3). The views of those who considered the course as unnecessary were luck of necessity of the course content for teaching profession (f=4) and complexity and detailedness of the course content (f=3).

Question #2: Do you think that the information provided in the course will help you in daily life? Please explain. 42% of the participants indicated that the information provided in the course will help them in daily life and remaining 58% indicated an opposite view. The view of those who thought the course as helpful for daily life generally focused on improvement of the skill of looking events from a broader perspective (f=5), development of analytical thinking (f=3) and preparation of the homework's (f=3). The views of those with negative opinion mainly cluster in fallowing categories: unrelatedness of course content with daily life (f=6) and lack of scientific research in daily life (f=7).

Question #3: Considering the knowledge you have acquired in the course, will it be beneficial while performing the teaching profession? 20 participants indicated that it will be beneficial, but the remaining participants indicated that it will not. The views of participants who said it will be beneficial mainly clustered on fallowing categories: conducting a research (f=8), assessment and evaluation (f=9), determining and finding solutions to educational problems (f=3) and ways to access information (f=4). The view of participants who said it will not be beneficial mainly categorized as follows: needlessness for teaching profession (f=4) and lack of application of knowledge (f=2).

Question #4: At most who do you think can benefit from information provided in the course? Participants indicated that academicians (f=15), graduate students (f=11), researchers (f=8), teachers (f=6) and preservice teachers (f=1) can benefit from information provided in the course at most.

Question #5: Where and for what purpose do you think the information provided in this course can be used at most? Participants' indicated that information provided in the course can be used in planning and conducting research (f=30), analysis of scientific data (f=7), writing a thesis/book/article (f=8), graduate courses (f=2), universities and research centres (f=10), and performing teaching profession (f=4).

DISCUSSION

Several researches indicated that students who attended research course had more positive attitudes towards research (Pearcey, 1995) and felt that they were better able to use research to improve their skill for their profession (Adamsen, Larsen, Bjerregaard & Madsen, 2003; Lacey, 1996). It is clear from the results, that overall, the students felt that the course can be useful mainly for academicians and researchers. Only minority of the participants indicated the importance and usefulness of the course content for teaching profession. However, most of them were unaware of the importance of research methods for teaching profession. This result could be attributed to the instruction, delivery of the content and inadequate course hours. The instructions are generally carried out by lecturing in two hours/week. Therefore, there was not enough time that can be spent for applications in which preservice science teachers can apply theory into practice, particularly related to field of education. Although some participants indicated that the course enhanced their skills such as looking events from a broader perspective, majority of them indicated that the course content is not related or beneficial for daily life and they also indicated that the information provided will be manly beneficial for academicians and researchers. Therefore, preservice science teachers were not aware of the usefulness of the course content for both daily life and teaching profession. These results present the necessity of further research about the effects of the course and how this course should be taught and what should be the course content and course hours. Adding application hours in addition to theoretical hours to the course should be discussed.

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PRESERVICE SCIENCE TEACHERS' CONCEPTIONS OF ANALYTICAL CHEMISTRY

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Abstract: Subject matter knowledge is important for teachers while they are performing their profession. In elementary level, teachers also should be able to provide answers for some daily life events and should be able to use daily life samples while they are teaching. This study aimed to investigate preservice science teachers' conceptions of analytical chemistry. A questionnaire composed of open ended items was administered to purposively selected 40 preservice science teachers. Results indicated that preservice science teachers think that the course is difficult and the content is detailed. Although some of them indicated that analytical chemistry knowledge is not required while they are teaching in elementary level, many others indicated that the course enhances their subject matter knowledge, problem solving skills and laboratory skills. Furthermore, majority of participants were not able to present enough number of appropriate examples for how analytical chemistry knowledge can be used in daily life.
Keywords: Analytical chemistry, pre-service science teachers, undergraduate course, daily life examples, pre-service science teachers' conceptions

INTRODUCTION

In recent years, researchers have shown a growing interest in the knowledge base of preservice science teachers. Preservice science teachers' conception of teaching and learning science or their views on teaching science or the ways they construct knowledge about teaching were analyzed by researchers (Van Driel, De Jong & Verloop, 2002). Many researchers also investigated the subject matter knowledge of preservice science teachers (Haidar, 1997). Subject matter knowledge is a key concept for science teachers while they are performing their profession. Therefore, science education programs include various chemistry, biology, physics and mathematics courses. The content of these courses is one of the major factors that empower students' subject matter knowledge that is important for teaching profession. Therefore, preservice science teachers receive several chemistry courses and analytical chemistry is one of those courses provided in the Turkish science teacher education program.

Analytical chemistry is concerned with the chemical characterization of matter and qualitative/quantitative analysis of it (Yuzhi, 2003; Skoog, West, Holler & Crouch, 2004). Analytical chemistry is a course for 2nd year (3th semester) undergraduate students majoring in science education (YÖK, 2007). It usually involves 22 hours of lectures and 22 hours of laboratory work. Most existing textbooks on analytical chemistry divide analytical science into fundamental and instrumental aspects (Otto, 2001). The content of the course in science education is mainly concerned on fundamental aspects such as gravimetric and volumetric analysis. Furthermore, teaching and learning of analytical chemistry is carried out using a didactic approach. Instructors deliver formal lectures to transmit knowledge; students receive it passively and are then expected to produce it accurately in the examinations. In the laboratories preservice science teachers perform experiments related to fundamental analysis and while performing these experiments they use commercial chemicals and daily life samples are generally not used in the analysis.

Analytical chemistry has a broad and detailed content and can be used in many fields (Valcarcel, 1992). Since science teachers will not serve as a chemist they do not have to know all the content in detail. However, the course provided in preservice science teaching program is similar to that provided in other departments. This detailed content needs to be criticized and some applications that require them to use daily life samples should be included. Therefore, in this study it was aimed to investigate preservice science teachers' conceptions of analytical chemistry and benefits of analytical chemistry knowledge to science teachers while teaching. Moreover, it was investigated whether they can provide examples of analytical chemistry applications in daily life.

METHOD

A qualitative research method was chosen to enable the participants to express their own views and to use actual participant statements as data. Therefore, a questionnaire was constructed to determine pre service science teachers' views regarding analytical chemistry course by the researchers.

Sample

Purposive sampling methodology was followed. Students who have enrolled to analytical chemistry course were selected as a sample of the study. Therefore, participants in this study were 40 pre-service science teachers enrolled in a one semester analytical chemistry course. The age of the students ranged from 19-21 years. Of the 40 students 29 were female and 11 were male.

Data collection instrument

A questionnaire consisting of open-ended questions was administered to each participant at the end of the course. The questions of the questionnaire are provided below.

- What are your positive views on analytical chemistry course?
- What are your negative views on analytical chemistry course?
- Is it necessary to include analytical chemistry course to science teacher education curriculum?
- Where do you think you can benefit from what you have learned in the analytical chemistry course while you are performing teaching profession?
- Please provide 10 examples on how analytical chemistry can be used in daily life.

Data analysis

The data collected from the open ended questions were analyzed by first conducting multiple passes through all written responses to each of the five questions. Each written response had been transcribed and categorized by question. Using interpretive content analysis participants' responses for common themes were analyzed by counting the appearance or frequency of specific units. Both researchers compared the themes identified and negotiated on these themes until they achieve consensus. The central themes were used as categories in further investigations. Then, a coding schema to track the thematic categories that emerged from participants' written responses was established. The written responses were reread and thematic indicators were count independently by each researcher. The inter rater reliability for coding the participants' written responses to the open ended questions was 90.0%. Next, participants' representative responses that identify the themes and some outlying responses that carries significant and powerful message were selected.

RESULTS

The findings of the study are presented according to the themes revealed in participants' written responses to the open ended questions. Excerpts from their responses are included to clarify the thematic findings.

Question #1: What are your positive views on analytical chemistry course? Participants' positive views mainly focused on usefulness of laboratory experiments (f=17), development of problem solving skills (f=14), enhancement of subject matter knowledge (f=10), helpfulness in daily life (F=10) and contribution to professional competence (f=5).

Question #2: What are your negative views on analytical chemistry course? Participants' comments generally focused on the detailed content (f=18) and difficulty of the course (f=13). Specific comments included: "Analytical chemistry course is to detailed for us", "I have difficulty in understanding what is taught". Few comments focused on the length of numerical procedures, work load, boringness of the course and similarity of the content with general chemistry course.

Question #3: Is it necessary to include analytical chemistry course to science education curriculum? Why? Most of the participants' (N=31) comments focused on the essentialness of the course. The main reason provided was that the course develops and increases the level of professional competence and their laboratory skills. Participants who said it is not essential mainly indicated that the content of the course do not match up with the content they will teach in elementary classes. A specific comment included: "elementary education program do not includes subject that require application of acquired knowledge in this course".

Question #4: Where do you think you can benefit from what you have learned in the analytical chemistry course while you are performing teaching profession? Participants' positive opinions clustered manly in three themes which are master the content (f=12), laboratory applications (f=21) and professional competence (f=22). Some students indicated that they will not benefit from analytical chemistry content while they are performing their profession. The main reason they provide was "we will not teach in elementary level in that detailed way".

Question #5: Please provide 10 examples on how analytical chemistry can be used in daily life. Participants' responses were grouped according to the number of appropriate examples. None of them were able to present appropriate 10, 9 and 8 examples. The frequency of appropriate examples is as follows: seven examples (3), six examples (4), five examples (3), four examples (9), three examples (9), two examples (7) and one example (4). Interestingly one participant indicated that "there is no example in daily life in which analytical chemistry knowledge can be used".

DISCUSSION

Preservice science teachers indicated that analytical chemistry course is helpful for the development of laboratory skills and subject matter knowledge. Therefore, they acquire necessary skills for teaching profession and increase their professional competences. However, they also indicated that analytical chemistry course is difficult and the content is too detailed. Furthermore, some of them said that they will not teach science in elementary level in that detailed way so detailed analytical chemistry knowledge is useless. The results also presented that preservice science teachers were not able to present appropriate examples for the usage of analytical chemistry knowledge in daily life. The content of the analytical chemistry provided in preservice science teacher education program as the preservice science teachers indicated is to detailed, heavy and the content is not so related with daily life. Therefore, the content of the analytical chemistry should be reevaluated and it should be arranged so that to include more daily life examples and applications. These will probably help preservice science teachers in both better understanding of the content and increasing their professional competence. Therefore, theoretical courses provided should comply better with actual professional needs.

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POTENTIALS OF LERNWERKSTATT (OPEN INQUIRY) FOR PRE-SERVICE TEACHERS' PROFESSIONAL DEVELOPMENT

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Abstract: In the debate about scientific literacy, the OECD considers an adequate understanding of science to be essential for becoming a reflective citizen, as it is an important basis for decision-making. Learning science through open inquiry is one contribution to reach this goal. Conducting open inquiry at school is a challenging task for teachers. To support them an appropriate learning environment for pre- and in-service teacher education needs to be provided. One learning environment to experience open inquiry and to prepare teachers for scaffolding their students which is offered by some universities in Germany, Austria and Switzerland is called Lernwerkstatt. The German term Lernwerkstatt seems to be the most appropriate one as there is no adequate translation.

To fathom the potentials of a Lernwerkstatt interviews with ten heads of Lernwerkstatt at universities were conducted and analyzed. In this paper the personal theories found in the interviews concerning the professional development through Lernwerkstatt in pre-service teacher education are presented. The personal theories found in the interviews could be related to theoretical backgrounds. Those are phenomenology, situated learning, learning environment, scaffolding and inquiry learning. Standards for pre-service teacher education were added to the analysis as a normative frame.

The results suggest that Lernwerkstatt is a learning environment where open inquiry can be experienced and one's own learning can be reflected. The interviewees stated that the experience of open inquiry makes pre-service teachers more aware of potential difficulties in learning processes and heightens the appreciation for these processes. The interviewees assume that pre-service teachers who have experienced learning in a Lernwerkstatt would use open inquiry in schools more frequently than pre-service teachers who did not have the opportunity to attend Lernwerkstatt courses.

Keywords: Open inquiry, pre-service teachers, teacher education, Lernwerkstatt

BACKGROUND, FRAMEWORK AND PURPOSE

In a modern society, life requires an adequate understanding of science and technology (NRC, 1996). It is important to be able to think creatively, solve problems and make decisions. In this context, scientific literacy is necessary to empower people to become responsible citizens (NRC, 1996; OECD, 2006). One way of becoming scientifically literate is to learn science through inquiry (NRC, 2000). For the implementation of inquiry learning into the classroom the education of (prospective) teachers should put greater emphasis on this aspect. In the National Science Education Standards the National Research Council (NRC) points out: *"[...] professional development must include experiences that engage prospective and practicing teachers in active learning that builds their knowledge, understanding, and ability"* (NRC, 1996, p. 56). Accordingly, Lernwerkstatt could be an adequate learning environment where pre- and in-service teachers can experience open inquiry. The term Lernwerkstatt could be translated as learning workshop but that is a very general term and is not considered as synonymic. Therefore, the German term is used. In this paper, the focus lies on pre-service teacher education.

There is not much literature about the theories behind Lernwerkstatt. Therefore, the main purpose of this study is to figure out which personal theories the heads of Lernwerkstatt have and to correlate them to established theoretical backgrounds to evaluate if Lernwerkstatt is qualified as a learning environment for professional development.

RATIONALE

The Lernwerkstatt concept was developed by Karin Ernst in Berlin, Germany, in 1980, mainly based on the New York workshop centre concept of Lillian Weber (Ernst, 1996; Weber, 1977). A Lernwerkstatt is described as a room where learners encounter stimulating phenomena, objects and materials which are supposed to trigger questions in their own field of interest for them to work on. In that room there are consumables like paper, cardboard, glasses, rubber bands, corks and so on, tools like hammer or cutting blades to start immediately with an inquiry.

Two key elements of Lernwerkstatt can be extracted from the literature:

- individual open inquiry learning opportunities are provided (Hagstedt, 2004)
- facilitators or coaches are needed who scaffold the learners' inquiry process (Zocher, 2000)

Inquiry in the classroom can be described by four levels (Blanchard et al., 2010) shown in Table 1.

	Source of the Question	Data Collection Methods	Interpretation of Results
Level 0: Verification	Given by teacher	Given by teacher	Given by teacher
Level 1: Structured	Given by teacher	Given by teacher	**Open to student**
Level 2: Guided	Given by teacher	**Open to student**	**Open to student**
Level 3: Open	**Open to student**	**Open to student**	**Open to student**

Table 1: The levels of inquiry (Blanchard et al., 2010, p. 581)

At level zero, the three key elements "source of the question", "data collection methods" and "interpretation of results" are given by the teacher whereas at level three the students are responsible for these three aspects. The work done in a Lernwerkstatt can be regarded as level three which is open inquiry.

Levels of Inquiry according to Bonnstetter (1998)	**Traditional Hands-on**	**Structured**	**Guided**	**Student Directed**	**Student Research**
Topic	Teacher	Teacher	Teacher	Teacher	Teacher/Student
Question	Teacher	Teacher	Teacher	Teacher/Student	Student
Materials	Teacher	Teacher	Teacher	Student	Student
Procedures/Design	Teacher	Teacher	Teacher/Student	Student	Student
Results/Analysis	Teacher	Teacher/Student	Student	Student	Student
Conclusion	Teacher	Student	Student	Student	Student
Level of Inquiry according to Abrams (2007)	**0** **Verification**	**1** **Structured**	**2** **Guided**	**3** **Open**	

Table 2: Assemblage of Abrams' (2007) and Bonnstetter's (1998) levels of inquiry

In Bonnstetter's (1998) description six elements in an inquiry process are mentioned. These are "topic", "question", "material", "procedures and design", "results and analysis" and "conclusions". Bonnstetter specifies five levels of inquiry, which can be related to the levels described previously.
Level zero matches Bonnstetter's "Traditional hands-on" where all elements are guided by the teacher. Level one and two are also called structured and guided. Inquiry of type three is divided into two types, "student directed" and "student research". At the type student-directed all elements except the topic are open to students; in "student-research" even the topic is chosen by students. Both types are common in Lernwerkstatt.
As previously mentioned, we wanted to find out which personal theories the heads of Lernwerkstatt have. Jarvis (1999, p. 145) wrote that *"personal theories consist of fully integrated knowledge that combines learning from doing and thinking about practice with learning from other information sources"*. Thus, the daily practice and the continuous reflection of the work the heads of Lernwerkstatt carry out are important.
To fathom the possibilities and potentials of Lernwerkstatt for pre-service teachers and to gain insight into the usage of open inquiry at pre-service teacher education the following research questions were posed: What are the specifications of a Lernwerkstatt? What goals do the heads of Lernwerkstatt at universities have for the work in their Lernwerkstatt in the context of pre-service teacher education? What is the expected impact of the Lernwerkstatt experience on pre-service teachers? Therefore, a selection of heads of Lernwerkstatt was interviewed.

METHODS

To understand the potentials and to identify the learning opportunities of a Lernwerkstatt an interview study was carried out. This qualitative approach was used to meet the objective of collecting and comparing the diverse perceptions of the interviewees.
Ten heads of Lernwerkstatt from Germany, Switzerland and Austria were selected for the interviews based on the following criteria: i) being head of a Lernwerkstatt at their respective universities, ii) conducting teacher education and professional development programs.
Expert interviews were made manual-aided with narrative elements (Meuser & Nagel, 1991). The manual contained requests like "Could you describe your Lernwerkstatt?" or "What do you think are the effects of the Lernwerkstatt courses you offer?" The interviews were conducted at the respective interviewee's Lernwerkstatt and took about an hour each. They were done between August 2009 and March 2010, anonymized and analyzed using qualitative content analysis according to Mayring (Flick, 2009; Mayring, 2008) to extract the personal theories of the interviewees concerning the three research questions. After extracting the personal theories their correlation to the relevant theoretical backgrounds were discussed within the working group. Those connections between the personal theories of the interviewees and the correlating theoretical backgrounds are shown in the results.

RESULTS

In the following three sections the three research questions are addressed. The extracted personal theories are connected to theoretical backgrounds underpinned by quotes from the interviews.

Specifications of a Lernwerkstatt

The results of the interviews show that the physical room of the Lernwerkstatt is considered to be important for an inquiry process. The purpose of the room is to create an atmosphere which triggers questions in the pre-service teachers' minds. One interviewee said: *"I think, it's the atmosphere of the room. [….] to create an atmosphere which initiates learning and* *communication"* (I1, 118) [1]. The *"atmosphere of the room"* is not only interpreted as the material environment (Fraser, Anderson, & Walberg, 1982), as a room with interesting objects, but as a complete learning environment. A learning environment contains many aspects. It is an arrangement of methods, techniques, materials and media (Reinmann & Mandl, 2006) contributing to the inviting and curious-making *"atmosphere"*. A learner-centered approach is used (Bransford, Brown, & Cocking, 1999) where the focus is on the learner with his/her previous knowledge, experience and interest.

The heads of Lernwerkstatt consider the objects in the Lernwerkstatt as central tools to trigger an inquiry process. The presented phenomena initiate investigations. A quote from an interviewee: *"That's basically the starting point, the amazement and wonderment. Then they [the pre-service teachers] carefully approach to a phenomenon […]"* (I3, 49). The corresponding theoretical background is the phenomenological approach. Buck (2006) writes that through interaction between the person and the object understanding is constituted. On behalf of the objects there is an emphasis on the perception through one's senses (Østergaard, Dahlin, & Hugo, 2008).

In a Lernwerkstatt it is central that the learners inquire a question of their own interest and take the complexity of a phenomenon with all its conditions into account. A community of practice is created among the pre-service teachers and the heads want to foster communication and reflexivity. An interviewee stressed: *"They [the pre-service teacher] are forced to let the others know about their learning path and to reflect it"* (I3, 25). All these previously mentioned conditions get in line with the theoretical background of situated learning (Bircher & Schmid, 2006; Gerstenmaier & Mandl, 1995; Lave & Wenger, 1991). That determines authenticity, complexity, social interactions, problem orientation, communication and reflexivity as significant to promote learning.

Goals of the heads of Lernwerkstatt for their work

The research question of an inquiry is often hard to find and hard to phrase. Also, the pre-service teachers are often not used to conduct an investigation and to reflect the methods they use. The abilities to conduct an inquiry like to *"identify questions"* or *"design and conduct scientific investigations"* (NRC, 2000, p. 19) which should be developed during teacher education as they were often not addressed in pre-service teachers own school-careers.
The interviewees wanted to emphasize on the necessity to learn how to do inquiry and how to pose a research question. One of them said: *"They [the pre-service teachers] have learnt to give answers. […] to phrase a question, that's not easy!"* (I6, 194).

Vital to the success of the students during open inquiry is how they are being scaffolded during their process. In the Lernwerkstatt, teachers often stay attentively in the background and support the learners when needed. To develop these competencies the pre-service teachers take the role of learners being scaffolded. More and more, they change their role: *"The pre-service teachers undertake a transformation process from learner […] to teacher who can scaffold students themselves"* (I3, 29). In the analysis of the interviews it appeared that the pre-service teachers have the possibility to do inquiry themselves and discuss that experience on a meta-level. But only one Lernwerkstatt was able to contribute the opportunity to work directly with students to the prospective teachers. All other heads of Lernwerkstatt have to refer the pre-service teachers to internships at schools to practice their scaffolding skills, but without supervision and reflection by the Lernwerkstatt educators. For the teacher educators it is important that the pre-service teachers experience scaffolding themselves and that they transfer the knowledge about scaffolding into their own teaching. The interviewees stated that the experience of open inquiry makes pre-service teachers more aware of difficulties in learning processes and heightens the appreciation for these processes. As the learners are responsible for their inquiry process a new teacher role is required (De Jong & Van der Valk, 2007; van der Valk & de Jong, 2009). Scaffolding can be provided in various ways e.g. by asking open questions or reflecting students' comments (Furtak, 2006, 2008; van Zee & Minstrell, 1997). In the literature about Lernwerkstatt the following ways of scaffolding are additionally highlighted: to appreciate the learner's way and to provide support, sources and materials when needed (Zocher, 2000).

An overall goal for the heads of Lernwerkstatt is to engage pre-service teachers in inquiry learning, showing them an additional teaching method and ways of how to provide the learning environment "Lernwerkstatt". The heads think that all these parts are necessary to implement open inquiry learning in school. The reported claims the heads of Lernwerkstatt have can also be found in the NCATE (National Council for Accreditation of Teacher Education) Standards as normative goals (2008, p. 70), for example: *"they [science teachers] understand multiple methods of inquiry and engage students in scientific inquiry …"*.
Additional normative goals for the heads of Lernwerkstatt are that their pre-service teachers gain personal experience and reflection competence as well as to be aware of their own biographical learning experience. *"They [the pre-service teachers] have to recognize the educational socialization they have experienced"* (I3, 25), an interviewee mentioned. That approach can be found in the German KMK Standards (2004). These standards determine the goals which have to be achieved by teacher education as well as recommendations how these goals could be attained e.g. by *"personal testing and reflection of concepts in role play, simulated or real lessons"* or *"analysis and reflection of the own biographical learning experiences"*(KMK, 2004, p. 6).

Impact of the Lernwerkstatt experience on pre-service teachers

"We [the heads of Lernwerkstatt] are working with creeds. We have not done empirical research" (I3, 26), one interviewee said. Another one mentioned in the interview: *"I hope so [that we have impact], but we haven't done any research projects"* (I2, 98). The teacher educators in the Lernwerkstatt refer only to personal experience and just a few cases from former pre-service teachers who came back to the Lernwerkstatt as teachers. It is assumed by the interviewees that pre-service teachers who have experienced learning in a Lernwerkstatt will use open inquiry in schools more frequently than pre-service teachers who did not have the opportunity to attend Lernwerkstatt courses. They criticize the missing empirical research themselves.

Summing up, the extracted personal theories of the heads of Lernwerkstatt correspond to five theoretical backgrounds. These are phenomenology, situated learning, learning environment, scaffolding and inquiry learning. The standards for pre-service teacher education were added as a normative frame.
Even if the heads of Lernwerkstatt do not explicitly mention those theoretical backgrounds in the interviews, they underlie implicitly the principles and goals of the courses in the Lernwerkstatt to support learning.

CONCLUSIONS AND IMPLICATIONS

During pre-service teacher education, prospective teachers should become familiar with the variety and scope of teaching and learning methods, which can be used at school. As inquiry learning gains importance in science education it has to be integrated into teacher education (Rocard et al., 2007). For pre-service teachers Lernwerkstatt seems to be a suitable option to

initiate a professional development process in the field of inquiry learning: gaining experience in doing open inquiry themselves, discussions within the community about the experience and reflection out of two perspectives, out of the learner's and of the teachers' point of view. All these activities help the pre-service teachers to implement scaffolding into their own teaching.
The prejudice about Lernwerkstatt that there is no theory behind it is widely spread. In fact there is little literature. So we connected the personal theories of the heads of Lernwerkstatt to existing theories about learning. Thus, theoretical backgrounds from other contexts can be consulted to establish a Lernwerkstatt.
Further empirical research focussing on the learning process and professional development of pre- and in-service teachers is conducted. In future conceptions of pre-service education programs enough time should be granted for one's own inquiry learning experience, reflection and the practice of scaffolding skills. The latter is profoundly underrepresented in a current Lernwerkstatt. Interviews with teachers about their Lernwerkstatt experiences and case studies of learners at Lernwerkstatt at different ages will be done to gather empirical evidence about the impact of doing open inquiry in a Lernwerkstatt on the professional development of pre- and in-service teachers.

[1] The number indicates the position in the transcript of the interview.

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LEARNING TO IMPLEMENT SCHOOL EXPERIMENTS IN A BLENDED LEARNING APPROACH: AN EVALUATION STUDY

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Abstract: This paper reports about the redesign of a traditional course on school experiments in physics that is part of the teacher education program at the University of Potsdam. A blended learning approach was chosen to improve the course in the sense of (1) a stronger focus on aspects of pedagogical content knowledge related to experiments, (2) an increase of time on task, and (3) fostering communication processes. The face-to-face lab course existent before was combined with online activities implemented by means of a mixxt-community. The implementation of the blended learning scenario was accompanied by an evaluation study that aimed at surveying students` perception of their gains in competencies and of the communication processes related to the course. The results presented in this paper are based on data collected with a questionnaire consisting of scales on perceived increase in subject matter knowledge, in experimental competencies, in nature of science knowledge and in aspects of pedagogical content knowledge. Results indicate that students appreciate the course in total, because it facilitates increase of competencies in all facets that were surveyed by the questionnaire. Yet, at the same time, students rate the influence of the online activities as put into practice in this course as rather low. The time on task effect shows up to be relevant in particular for the acceptance of the online activities. Consequences for an improved blended learning design and further evaluation are discussed.

Keywords: blended learning, hybrid course, school experiments, teacher education, evaluation study

BACKGROUND, FRAMEWORK, PURPOSE

The University of Potsdam holds a strong tradition in physics teacher education. As an important part of their studies in physics education students have to take a course in which they learn to conduct and to stage school experiments in the domain of physics. Experiences with this course - being a mixture of seminar and laboratory work - were twofold, so far. On the one hand, students are enthusiastic and motivated while conducting the experiments. They usually increase their abilities in staging and conducting experiments indeed. On the other hand, the authors found students showing up unprepared and struggling with content knowledge in physics, which we assumed to be already understood by the students. Hence, students paid little attention to topics related to pedagogical content knowledge in the field of school experiments (PCK) (Shulman, 1986) and did not develop the competencies we intended.

For improvement a blended learning approach was chosen (Bonk & Graham, 2005), sometimes also referred to as a hybrid course (Garnham & Kaleta, 2002). By definition “Blended learning arrangements combine technology based learning with face-to-face learning” (Kerres and de Witt, 2003). General expectations associated with blended learning relate to the improvement of students’ learning outcome and of quality of teaching. Access to learning opportunities and flexibility of learning are supposed to be increased while costs are reduced (Graham 2005).

The intention for our course was more specific and threefold. We aspired (1) to increase students' time on task, (2) to establish a continuous learning process and (3) to give additional opportunities for communication about experiment related PCK. One of the competencies students should have developed as a result of the course was to give reasons, objectives and purposes for using a certain experiment in a specific classroom context. Evidently, these are reasonable objectives or even key competencies for future physics teachers which have received quite some research attention within the science education community (e.g. Hart et al., 2000; Jacobsen, 2008 and the review article Lavonen et al., 2004).

To support our objectives, we used a social community (www.mixxt.com) as a supplement to our lab classes which, obviously, required physical attendance. The structure of the resulting hybrid course is shown in figure 1. All online activities are marked with an asterisk (*). The face-to-face course continued to focus on practical aspects of preparing and staging experiments for school physics. Direct interaction between students as well as between students and instructors took place here. The online activities in preparation of the laboratory work consisted of tasks to be worked out by the students. E.g. the students had to report on relevant pupils' misconceptions in the content area, they had to specify learning goals related to their experiments and they were asked to exemplify one experiment in greater detail. Furthermore, students were encouraged to comment on the work of the others in the sense of a feedback culture. The instructors of the lab course were asked to give online feedback as well and to give advice for improvement of the work done.

It was pointed out to the students that the online activities played an important role in the preparation of the face-to-face course and the assessment at the end of course. Anyhow, participation was voluntary. See figure 2 for an exemplary screenshot taken from our mixxt community.

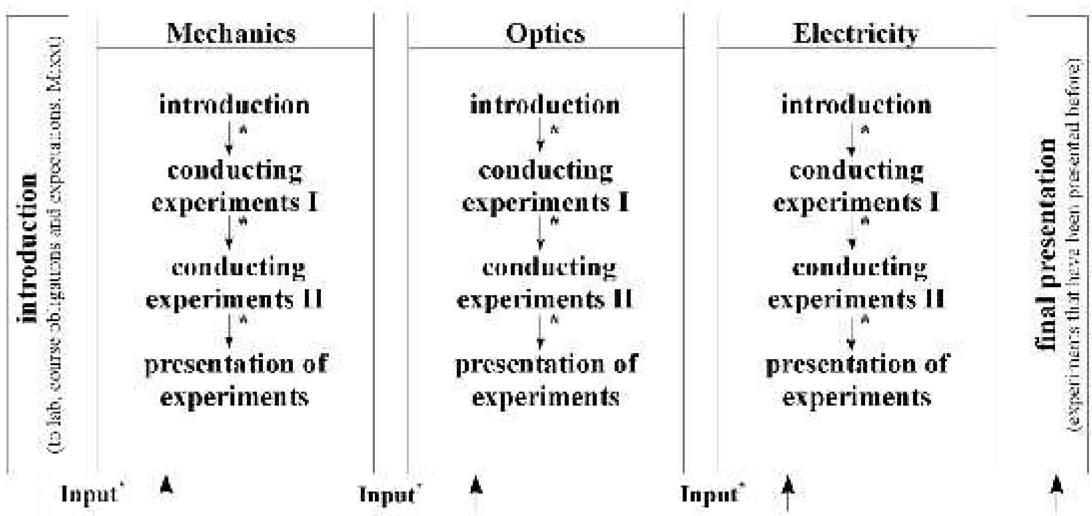

Figure 1: Structure of the blended learning scenario implemented in a lab course on school experiments in physics

The implementation of the blended learning scenario was accompanied by an evaluation study to gain an insight into the outcome of the design. Our interest - besides aspects of practicality or convenience of the hybrid format - concerned the students' acquisition of competencies. In particular, we wanted to learn about students' competencies in the subject matter and experimentation, their pedagogical content knowledge with reference to school experiments and knowledge of the nature of science as a result of the newly added online activities.

Due to the small number of students and reasons of fairness it was not possible to conduct a comparative study between a course with the blended learning structure and a course in the traditional format. Additionally, at that point of time no reliable instruments for direct measurement of the competencies mentioned before were available. Therefore, we decided to survey the increase of competencies as perceived by the students on the basis of overall course on one hand and cause by the online activities on the other hand.

Figure 2: Screenshot of the mixxt community

METHODS

A multi method approach was chosen to evaluate our course. Observations were conducted by one of the authors not directly involved in the teaching of the face-to-face course. Qualitative data from interviews with the teaching staff member and students were collected. Furthermore detailed protocols of students' and teachers' online activities are available (Rau et al., 2012).

Last but not least, a questionnaire including open ended questions and closed likert scale items (4-level, 0=no agreement, 1= little agreement, 2= some agreement, 3=full agreement) was employed. It is mainly the quantitative data resulting from this questionnaire that is presented and discussed in this paper. Scales were designed for our special evaluation interests as mentioned above. The factorial structure (main component extraction, promax rotation) and reliability of the chosen constructs was analysed and scales were identified. These scales were, then, used for analyses of correlation and variance. Our study included 19 teacher students (6 females), which explains why the final scales consist of very few items. As a first result, we were able to identify the scales shown in table 1 (together with their reliability coefficients (α), mean values (M) and standard deviations (SD). Moreover the questionnaire collected some personal data of the students and the estimated time they spent on online activities per week.

Scale	**caused by overall course**	**caused by online activities**
SMC perceived increase in subject matter competencies (4 items) *e.g. "I do understand the topics of physics."*	α=.74 M=2.12, SD=0.41	α=.80 M=.75, SD=0.54
ExpC perceived increase in experimental competencies (3 items) *e.g. "I can show specific phenomena by means of experiments."*	α=.66 M=1.81, SD=0.37	α=.95 M=0.36, SD=0.53
NoSK perceived increase in nature of science knowledge (3 items) *e.g. "I can explain the interrelation between models, experiments und laws in physics."*	α=.71 M=1.95, SD=0.51	α=.88 M=0.60, SD=0.61
PCK perceived increase in experiment related pedagogical content knowledge (4 items) *e.g. "I can anticipate problems in the realization of a certain experiment."*	α=.67 M=1.80, SD=0.55	α=.76 M=0.61, SD=0.48
CommPA perceived positive influence of mixxt on communication during physical attendance (5 items) *e.g. "The online activities fostered the interaction with the instructor."*	α=.75 M=1.13, SD=0.57	
CommOn perceived positive influence of mixxt on online communication (3 items) *"e.g. "The online activities encouraged the subject related interaction between students."*	α=.76 M=1.11, SD=0.64	
MixxtC competence using the mixxt community (4 items) *e.g. "The use of the online platform was easy to learn."*	α=.80 M=1.88, SD=0.63	

Table 1: Statistics of Scales

RESULTS

The handling of the mixxt community was not much of a problem for our students, as the mean value (see table 1, MixxtC) indicates. In contrast to our intention, the online activities were not perceived as very supportive for communication processes – neither online nor during the on-site time (see table 1, CommPA, CommOn).

The highest perceived increase in competencies was found for subject matter competencies (see table 1, SMC). This effect is independent from students' prior knowledge in experimental physics as an ANOVA (students have been assigned to a low, medium and high achieving group based on their grades in experimental physics) shows ($F(2;16)=1.06$, $p=.369$). This result can be explained with reference to what Riese (2010) found, namely that school related content knowledge is central for successful teaching but does not play an adequate role in physics teacher education. The perceived influence of the online activities on this increase in subject matter competencies is not a strong one, but it is existing independently from prior knowledge ($F=(2,16)=.68$, $p=.51$) (see table 1, SMC). A corresponding result can be found for the perceived increase in experimental competencies due to overall course ($F(2,16)=2.96$, $p=.081$) and due to the influence of mixxt ($F(2,16)=1.27$, $p=.308$) (table 1, ExpC).

Further, students perceived an increase of their NoS knowledge and - as we intended - also their experiment related pedagogical content knowledge (table 1, NoSK). Here again, the overall increase as well as the impact of the mixxt community activities are perceived, but not very strongly. As one would expect based on the literature (Kunter et al., 2007), subject matter proficiency (SMC), NoSK and PCK influence are highly correlated with each other, at least - and this is somewhat remarkable - for the part that was attributed to the online activities: $r(SMC,PCK)=.48^{*}$, $r(SMC, NoSK)=.71^{**}$. The same applies to reported gains in subject matter competencies and the experimental competencies: $r(SMC, ExpC)=.68^{**}$.

Of little surprise is the fact that the time on task – as estimated by the students themselves - provides a good predictor for the perceived increase in subject matter competencies. An ANOVA shows that the perceived increase is different (strong effect) for two contrast groups (split half): While students in group 1 investing $M=3.33$ hours per week ($SD=.78$) into course related activities on average perceived a reasonable increase ($M=1.94$ $SD=.32$), students in group 2 in average investing $M=6.57$ hours per week ($SD=2.94$) perceived a higher increase ($M=2.43$, $SD=.37$). This difference is statistically substantiated ($F(1;17)=9.15$, $p=.008^{**}$, $\eta^2=.35$). The same tendency can be found for the increase that was perceived due to online activities ($F(1;17)=7.67$, $p=.013^{**}$, $\eta^2=.31$). This also allows the conclusion that a positive effect of mixxt community activities is dependent on some dedication to that activity.

CONCLUSION

Students appreciate the course as being successful in offering learning opportunities and state a slight, but existent impact of online activities on the increase of competencies. Against our expectations, the influence of the blended learning approach was rather small or the questionnaire was not a commensurable instrument for measurement. Time on task was enhanced for at least some of the students. This leads us to generally following up the chosen approach. Still there is room and need for further improvement concerning the following aspects. We have to find ways of activating more students to take part in online activities to a full extent and on a deeper level of reflection. A stronger linkage between online activities and face-to-face communication could help to reach the full potential of a social community in the above described sense (continuity of the learning process and opportunity for communication). At first glance, qualitative data suggest that the (online) activity of the teacher trainer might be a crucial factor to foster students' activity as well. Therefore, it seems promising to train and brief the teacher trainers, to tie together the parts of the hybrid course and to support the continuity of online activities of students. Furthermore our instruments should be refined and supplemented e.g. by a scale measuring the motivational impact of mixxt activities. A design including control groups could help to objectify the subjectively perceived increase in competencies and direct methods of measurement of competency gains should be considered.

FUTURE PROSPECTS

The first insight into the implementation of a blended learning scenario in the teacher education program as presented in this paper is encouraging enough to follow up the chosen approach. Still, some lessons have been learned.

Concerning the technical realization we will substitute the mixxt community by wikis. We chose wikis, for substantial reasons as well as pragmatic ones. First of all our improved course design changes from voluntary documentation, reflection and discussion (for which the blog tool of mixxt.org was fitting well) to obligatory tasks that are constructed to prompt an in-depth study of certain aspects that play an important role in the process of preparing, conducting and reflecting a school experiment. The product of our students' learning effort is a wiki page which looks at a certain experiment from many perspectives and which has been improved and refined many times before it is finalized. The wiki based implementation also allows building up a database of physics school experiments. Finally the administrative effort (account setup, user and group management) is reduced.

To increase the students' engagement in online activities, and thereby, the time on task, a minimum of online activity was defined as a requirement for lab course attendance. Tasks for the students are specified and the format and complexity of the expected answers are clarified to the students. A joint project of all students in the course, the development of a database for school experiments in physics, is meant to increase the collaborative character of the online tasks. Future instructors of the lab course will be trained in attending the online activities in a supportive way. Here, an essential issue arises in that not only students' time on task is enlarged but also teachers' "time on work" is increased.

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PRE-SERVICE SCIENCE TEACHERS' METACOGNITIVE AWARENESS ABOUT LAB INSTRUCTION AND THEIR COMPETENCY IN INQUIRY LAB DESIGN: THE CASE OF A LAB APPLICATIONS COURSE

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Abstract: The study investigated whether pre-service science teachers' metacognitive awareness about teaching science and lab instruction change throughout a laboratory applications course. The course aimed to improve pre-service science teachers' inquiry lab design. So, it was designed to consist of interactive lectures, discussions, micro-teaching practices, and writing reports of micro-teaching practices. 33 pre-service science teachers participated in the study. Data were gathered through pre- and post-course evaluation forms, instructional design instrument (ID), and student reports. The results showed that students developed their metacognitive awareness about science teaching and lab instruction by means of the improvement of their competence of inquiry lab design throughout the course.

Keywords: teacher training, inquiry lab design, metacognitive awareness

INTRODUCTİON

One of the aims of science education is to enable students to understand not only the scientific concepts but also the process of scientific inquiry (Shimoda, White & Frederiksen, 2002). Inquiry has long been addressed as a useful approach for effective science teaching (Ottander & Grelsson, 2006; Mugaloglu & Saribas, 2010). Yet, there is no single definition of inquiry. National Science Education Standards (NSES) defines three main types of inquiry, one of which is 'inquiry as teaching'. The present study focuses on inquiry as teaching, which refers to "the activities of students in which they develop knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world" (Anderson, 2002, p.23).

National Research Council (NRC, 2000, p10) states five features of inquiry. These are "(a) students engage in scientific questions which are posed by the students themselves or by the teachers, (b) students provide responses that prioritize evidence, (c) students propose explanations based on evidence, (d) students evaluate their proposed explanations in light of alternative explanations and accepted scientific knowledge, and (e) students communicate and justify their proposed explanations". Schwab (1962, cited in Settlage & Southerland, 2007) proposes a scale of three levels for the application of inquiry science teaching. In this scale, in Level 0, the lowest level of inquiry, the teacher has the complete control over instruction and the students are provided with all the components of inquiry, which include question, procedure, and the results of the investigation. In Level 1, the teacher gives students the problem of the investigation and explains the method of the experiment while the students are expected to find out the results of the experiment. In Level 2, the teacher gives the question and expects students to come up with their own procedure to solve the problem and conclude. In Level 3, the students have the full responsibility over the investigation and they are given none of these three components (Settlage & Southerland, 2007). Moreover, in recent years, metacognition has been considered as an important variable in learning science. Many researchers stated that metacognitive processes promoted meaningful learning, or learning with understanding (Gourgey, 1998; White & Mitchell, 1994; Rickey & Stacey, 2000; Saribas & Mugaloglu, in press). In a study conducted by Saribas & Bayram (2009) metacognitive development in chemistry lab improved pre-service science teachers' science process skills.

Within this frameworks, the aim of the present study was to investigate how pre-service science teachers' metacognitive awareness about lab instruction change with the development of their competence in inquiry lab design throughout a lab applications course. In the lab applications course, as literature pointed out the positive effects of collaboration (Anderson, 2002) on students' inquiry learning and their approach to inquiry teaching students worked collaboratively on their tasks and discussed every step of the process both in groups and in the whole class.

METHOD

Sample. 33 pre-service science teachers who took Laboratory Applications-I course in 2009-2010 fall semester participated in this study. The sample consisted of 9 male and 24 female students.

Assessment. All the participants were administered course evaluation forms (CEFs) and instructional design instrument (ID) before and after treatment. Course Evaluation Forms (CEFs) were prepared by the researchers to assess pre-service science teachers' metacognitive awareness about teaching science and science lab instruction. Students were administered pre-evaluation form before instruction and post-evaluation form after instruction. The two forms consisted of the same questions with different tenses in some questions. Instruction Design Instrument (ID) was prepared by the researchers to evaluate students' capability to design an inquiry-based lab instruction. An authentic problem was given in this instrument and the students were asked to design an inquiry lab instruction based on this problem (Attachment 1). Students' answers to this question were scored according to the rubric the researchers developed based on Schwab's inquiry levels (Table-1).

Table-1. Rubric for ID based on Schwab's model

	0	1	2	3	Score
Inquiry level	Structured	Problem and procedure are given	Only problem is given	None of the components are given	
Formulating introduction	No introduction	Unclear introduction	Clarifies aim or problem	Leads to inquiry	
Formulating procedure	Insufficient	Procedure is strictly given	Partially defined	Guide students to define their own procedure scientifically	
Formulating results and conclusion	Insufficient	Structured	Guides students to make conclusions (posing questions)	Guide students to make evidence based conclusions	

Procedure. The participants were exposed to an 11-week program including interactive lectures, discussions, micro-teaching experiences and reports of these experiences related to the design of inquiry-based lab instructions. The treatment was implemented in two different classes of students enrolled in fall semesters of the instructional years of 2009-2010 and 2010-2011 consecutively. Before treatment the students were administered pre-CEF and ID. Then students were divided into 6 groups in one semester and 5 groups in the other semester. Each of the groups included 3 or 4 students. In the first week of the treatment an interactive lecture about experiment and lab instruction were carried out. The focus was on experiment and types of lab work such as deductive, inductive, technical skills, science process skills lab and problem solving skills lab on this class hour. In the second week, lecture and discussions were carried out about inquiry and inquiry lab instruction on the basis of Schwab's levels of inquiry. The third week of the program focused on science process skills with some interactive activities. During these three weeks, the participants were responsible for designing a lab instruction on a predetermined environmental topic with their teammates. In their first micro teachings, students were free to design their lab instruction in any inquiry level. All the students prepared the reports of their microteachings including their individual reflections regarding the effectiveness of the instruction, and theories and methods discussed in previous lessons and used in the activities during micro-teachings. After micro-teaching experiences, the students responded ID in order to examine whether there was an improvement in their competence of lab instruction and the inquiry level they preferred to design in their instruction. Interactive lectures continued in the seventh and eighth weeks. In the seventh week, students were lectured about lab instruction styles such as expository, problem-based, discovery (guided-inquiry), and open-inquiry instructions. In the eighth week, the topics of cooperative and collaborative learning and peer review were discussed. Inquiry was the focal point of these two-week class hours. The students were responsible to design a lab instruction about any science topic. In the following two-weeks the participants presented their second micro-teachings collaboratively. During the course, after each micro-teaching, discussions were carried out about the effectiveness and the inquiry level of each presentation as well as lab instruction style, and the components of cooperative learning they used in the activities. Moreover, all participants prepared reports to reflect on their microteaching experiences. However, students' 2nd reports differed from their 1st reports in terms of assigning roles to each member of the groups for the purpose of implementing peer review in writing reports. One member of the groups was assigned as primary author, the other was assigned as editor, and the last one (or two) was/were assigned as technical reviewer. In the last three weeks the students presented their second lab instructions. After the 11-week program, all participants were administered post-CEF and ID.

RESULTS AND CONCLUSİON

Table-2 indicates that pre-service teachers had a significant improvement in terms of inquiry as a result of paired samples t-test.

Table-2: Results of inquiry design

	Paired Differences							
	Mean	Std. Deviation	Std.Error Mean	95 % Confidence Interval of the Difference			df	P
				Lower	Upper			
Pre-level – Post-level	1.67	0.92	0.16	-1.99	-.1.34	10.36	32	0.00
Pre-intro – Post-intro	2.12	1.22	0.21	-2.55	-1.69	10.00	32	0.00
Pre-procedure – Post-procedure	1.48	0.83	0.15	-1.78	-1.19	10.23	32	0.00
Pre-conclusion – Post-conclusion	1.64	1.08	0.19	-2.02	-1.25	8.67	32	0.00

Pre-inquiry –post-inquiry	6.91	2.45	0.43	-7.78	-6.04	16.17	32	0.00

Before the treatment, 48.5% of the participants referred to the need of improvement in knowledge and skills for designing and implementing lab instruction. After the treatment, all the participants addressed the knowledge and skills required for instructional design such as inquiry levels, method of instruction and/or science process skills. However, before the intervention they only emphasized a need for design in general terms. In other words, after the intervention participants' awareness of the need of knowledge and skills in designing and implementing lab instruction enhanced and varied throughout the study.

This result indicates a rise in metacognitive awareness of students in terms of teaching science and science laboratory instruction, after the treatment. It is consistent with the literature that points out the positive effect of inquiry laboratory for the development of metacognitive skills (Kipnis & Hofstein, 2008). National Research Council [NRC] (1996) suggests designing science curriculum emphasizing on inquiry skills. Mumba et al. (2007) advocates that syllabus and practical examinations for inquiry levels and inquiry skills are desirable for science educators. Further study, therefore, investigating pre-service science teachers' syllabus and assessments emphasizing inquiry levels and inquiry skills may have remarkable contributions to their inquiry lab design, their metacognitive skills as well as their approach to enhancing students' metacognitive and inquiry skills.

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Attachment 1

Designing a science lab:

What is the best type of a soil to prevent flood?

Following the disaster in Istanbul, Ms Dogan, the science teacher of 8th graders, decided to encourage her students to find a way to prevent flood for an inquiry science lab. Below you will find her notes about definition of flood, her question and the materials in the lab. Please design the lab plan to complete her work:

Notes of Ms Doğan:
Definition of flood: It is an overflowing of water onto land.
Question: What is the best type of a soil to prevent flood?
Materials: Any glassware, graduated cylinder, different types of soil, stopper, Water, Stopwatch or any extra material

SUPPORTING PRE-SERVICE TEACHERS IN DESIGNING AUTHENTIC LEARNING ENVIRONMENTS IN CHEMISTRY LESSONS

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Abstract: Authenticity has recently become a popular term in science education. A study focusing on authenticity in the sense of making chemistry lessons resemble chemistry practice is carried out at the University of Cologne in the Institute of Chemical Education, where prospective chemistry teachers are trained. It has started in April 2010 and is an ongoing project. The short term aim is to challenge teacher students' pre-conceptions about characteristics of chemistry and chemical research. In the long term school practical-relevant elements of these characteristics are going to be embedded into teacher education courses. To achieve the short term aim a two-step approach was designed: at first elements to stimulate reflection on students' attitudes were identified. In a second step these elements were combined with an opportunity for teacher students to transform their reflected views of chemical research into a practical activity for pupils. In the long run these activities are going to be used to identify school practical-relevant elements in order to support pre-service teachers in designing authentic learning environments.

Keywords: Authenticity, learning environments, authentic chemistry lessons, pre-service teacher education

INTRODUCTION

Authenticity is a catch-word not only in everyday-life but it has recently become popular in the field of science education, without a common understanding of this term. There is a distinction between 'authentic' related to 'the students' lifeworld' and 'authentic' related to 'the practice of a scientific community' (Barab, Squire, & Dueber, 2000). The later is described by the principle of "making science learning better resemble science practice" (Edelson, 1998, p. 317). In chemistry teaching this refers to the chemical research and the people involved. The pupils should not only be confronted with parts of the investigation and become 'researchers' themselves, but they should also acquire knowledge about chemistry and science, which is not necessarily achieved by only conducting experiments (Abd-El-Khalick, Waters, & Le, 2008).

Authentic learning environments are often rooted in the concept of situated learning. Learning is associated with and depends on the context in which it occurs (Lave & Wenger, 1991). Therefore, the design of learning environments and the activities within gain importance.

Brown et al. argue that learning is also a process of enculturation and define “authentic activities […] as the ordinary practices of the culture” (Brown, Collins, & Duguid, 1989, p. 34) as a contrast to most school activities which lack context and thus cannot support structuring of students’ conceptions.

Related to these arguments is the concept of scientific literacy, a main goal of science education in school (Programme for International Student Assessment, 2004). Authentic activities in science lessons offer one possibility to promote this goal because they are “the only way [learners] gain access to the standpoint that enables practitioners to act meaningfully and purposefully” (Brown et al., 1989, p. 36).

In Germany the demand on scientific literacy can recently be found in educational standards (Kultusministerkonferenz, 2005). The competences are divided into subject knowledge, application of epistemological and methodological knowledge, communication and judgment (Schecker & Parchmann, 2007). These four aspects correspond to characteristics of chemistry (and scientific practice in general) such as content knowledge, thinking skills, scientific approach and social interaction (Chinn & Malhotra, 2002; Lee & Butler, 2003). Thus the claim for changing science lessons matches the call for more authentic learning environments.

Most of the examples in literature address pupils in school. The question arises whether pre-service teachers are able to meet the call for authenticity, i.e. are they prepared correspondingly during their education to put these examples into pratice? According to Lederman (Lederman, 1992) teachers’ conceptions constitute a necessary but not a sufficient condition for translation of these conceptions into school practice, thus this study focuses on prospective chemistry teachers at University level with two main research questions:

1. How can teacher students be stimulated to reflect about their pre-conceptions of chemistry and chemical research?

2. How can teacher students be enabled to create authentic learning environments?

PROJECT

Within the project, which is embedded into a theoretical framework representing the state of research, different aspects have to be considered (see Figure 1). There is the level of characteristics of chemistry and chemical research, about which students develop certain images before and during their studies, mostly without reflecting them. They are called pre-conceptions and one part of the project focuses on challenging these views and on analyzing how the original images change. This is going to be called post-conceptions. Characteristics of chemistry and research cannot be transformed one to one into school lessons (Edelson, 1998; Reiners, 2000); therefore practical-relevant elements shall be identified. Thus criteria of chemical research are condensed into practical-relevant elements, which in turn are going to be aligned if they still match the initial criteria.

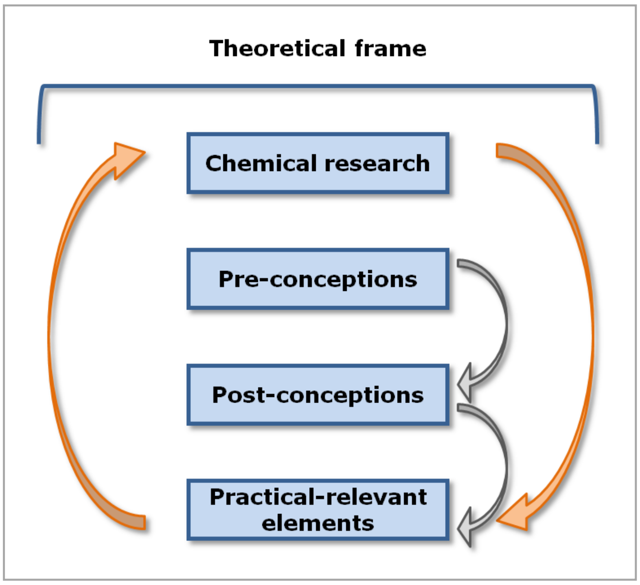

Figure 1: Overview project

To evaluate course elements that might be suitable to initiate teacher students' reflection about their views on chemistry (the step from pre- to post-conceptions), the course "Chemistry meets Chemistry Education" was designed in the summer semester 2010. The successful elements were maintained for the next course, in which they were combined with new course parts to approach the practical-relevant elements of chemistry and research.

This second course took place in the winter semester 2010/2011. 13 teacher students of chemistry (higher and lower secondary school, one for special education) participated, who were on average between the 7th and 8th semester. None of them participated in the first course. In the first part of the semester the students read and discussed various readings [1], which illustrated different aspects of chemistry and chemistry education. Another central part consisted of three talks of chemists given for the students, in which the scientists presented latest results in their field of expertise and gave an impression about their life as a chemist. The students were prepared for these talks by central scientific papers of the chemists and questions were gathered which the students wanted to ask. In the follow-up the talks were reflected and unclear issues were resolved. This part was to stimulate the students to reflect about their pre-conceptions. The discussion with other participants should help the students to critically contrast their own views with the ones of others. The first part ended up with formulating criteria of chemical research.

In the second part of the course the participants planned and conducted an out-of-school lab-day for a high-school class, in which a class came to our laboratories and were supervised by the students. With this lab day the students should convert the developed criteria into a practical activity. The students were free to choose the topic as well as the content and were only assisted by the course lecturers if necessary.

Research tools

For the study different research tools were used. Before the course the students filled out an open-ended questionnaire about characteristics of chemistry and chemical research in order to collect their pre-conceptions. During the semester a portfolio had to be written, thereby the students were free to use their own style. The only mandatory aspects were to reflect each lesson and voice their opinion as well as to make a purposeful reflection at the end in order to show how the initial image of chemistry and chemical research had changed. Approximately two months after the end of the course semi-structured interviews (Gläser & Laudel, 2009, p. 41) were conducted with each student, which were in parts related to the portfolio (for example to solve unclear issues), other parts were aspects of general interest for the study. The interviews were recorded and transliterated afterwards. Additionally the field notes taken by the researcher and the lab-day material developed by the students were used.

Analytical methods

To analyze the material a qualitative content analysis was used - the inductive category development according to Mayring (Mayring, 2008). A category system was created out of the obtained material and was guided by theory as well as by the research questions (Gläser & Laudel, 2009; Mayring & Gläser-Zikuda, 2008) [2].

From the questionnaires, portfolios and interviews individual profiles were generated in order to get insight in the learning process. Through the comparison of all profiles the first research question - if the course and its element were able to initiate reflection - was answered. Furthermore portfolios, interviews and field notes as well as the lab day material were used to find out how far the students have progressed on the way to a practical transformation, therewith contribute to answer the second research question. Especially the interviews served a double purpose: On the one hand they could reveal which conceptions were so concise that they still prevailed after some time. On the other hand they were used - together with field notes and lab day material - as a means of triangulation to validate the obtained results.

FINDINGS

First research question

All participants changed their pre-conceptions in the sense of correcting, broadening or concreting their previous views. The most common pre-conceptions (see Table 1) were *experiments and lab-work* as well as (*new) discoveries* and *progress*. The *picture of a chemist* as a (spectacled) male person who works alone in his laboratory was stated twice. In contrast to these common pre-conceptions three participants expressed more elaborated views (e.g. *no guaranteed results* or *using of these 'failed' experiments*), because they - unlike the rest of the group – had made prior experiences with (chemical) research.

Table 1: Most common named pre- and post-conceptions

Pre-conceptions	**Post-conceptions**	
	Category	
Experiments, lab-work (9)	Scientific approach	Experiments, lab-work (9)
New discoveries (5)		Discovery and creation (10)
		Various ways to do science (8)
		Experiments and theory (7)
	Epistemology	Theory and law (9)
		Chemistry is dynamic and evolves (5)
		Role of models (3)
		(Inter-)Subjectivity (6)
Image of a chemist (2)	Researcher personality	Creativity (11)
		Motivation and interest (8)
		Patience and frustration tolerance (6)
	Aims of chemistry	Objectivity (4)
Progress (4)		Progress (6)
		Pure and applied chemistry (7)
	Factors of influence	Ethical questions (7)
		Funding (6)
		Institutional conditions (5)
		Interdisciplinary approaches, collaborations (5)
		Not working alone (3)

The post-conceptions are divided into categories as described above (see Table 1). In the category 'scientific approach' - i.e. methods of science and how knowledge is obtained - the aspect *experiments* was still prevalent but it was complemented by several others. Also the students still stated *discovery*, but together with *creation*, for example the synthesis of new molecules. Especially by listening to the talks the participants realized that there are various ways to do science, for example they noticed that “one cannot plan everything. One has to use opportunities which arise […] there is no straight way for doing science” (Portfolio TA) [3].

Seven students explicitly connected *experiments* and *theory*, e.g. that “experiments are guided by theory” (Portfolio NA). This aspect is related to the category ‘epistemology’. Especially the terms *theory and law* were described more precisely at the end of the semester, for instance the development of scientific theories and therewith “chemistry research [as a] dynamic, advancing process” (Portfolio HS). Moreover the *role of models* was stated. Connected with these aspects is the factor of *(inter-)subjectivity* in science - for example the influence of the observer - which was a new issue for most of the students.

(Inter-)subjectivity is also associated with the category ‘researcher personality’. Due to the talks the students wrote and talked more about the ‘human’ aspects of research which play a role in doing science and being a chemist, such as *motivation and interest*, *patience and frustration tolerance* as well as *creativity*.

Though (inter-)subjectivity was realized as a part in science, the students also stated that science aims at being *objective* and “should communicate objective views” (Portfolio AZ). The aspects *progress* as well as *pure and applied chemistry* can also be included in the category ‘aims of chemistry/science’.

Other factors influencing research were mostly new to the participants, for example the aspects *ethical questions*, *funding* or *institutional conditions*. Connected with this category as well as with the category ‘scientific approach’ are *interdisciplinary approaches* and *collaborations* among scientists, which represented new aspects for some of the students. Additionally three people said that a chemist does *not work alone*; two of them were the ones who had initially imagined a chemist as “a little man alone in his laboratory [which] is definitely not true, you are not alone, only then scientific working is possible” (Portfolio LR).

According to these results the pre-service teachers were able to correct their prior conceptions through the course and its elements. The stimulated reflection was perceived as meaningful and important by the students: on the one hand for themselves as future teachers (8 students) and on the other hand for their future pupils (9). A lot of students expressed ideas about how to convey an image of chemistry into school lessons, e.g. by visits to research groups, which could demonstrate that chemistry is theoretical and practical work as well as social interaction. Furthermore they suggested using a historic approach to show the human aspects of chemistry as well as the development of theories.

Second research question

For the actual transformation of their post-conceptions into a practical activity for pupils - the out-of-school lab-day - the students chose the topic ‘A Chemical Winterday’. They developed five stations: ice-skating, heating pads, thermal conductivity, de-icing and separating processes. The students tried to implement some of the characteristics of science and chemistry in this day, e.g.:

- *Problem-solving* was used by some of the groups, for example in the separating process group the pupils had to separate an unknown (winterly) alloy with prior learned methods.
- *Self-reflection* was part of the thermal conductivity group, in which the pupils could learn something about the influence of the observer.
- *Hypothesis testing* and *environmental aspects* were implemented by the de-icing group; the pupils had to find out the best de-icer without being dangerous for the environments.

The students also experienced some difficulties during the planning of the lab-day. One of the problems was that the participants were unsure how to transform the criteria into a practical activity and how to start, i.e. to take one criterion which is considered important or interesting for the pupils and then try to find an adequate content or to approach this vice versa (7 students). Finding adequate experiments and creating appropriate learning materials turned out as another difficulty (6). Furthermore some of the participants stated that they have not made many experiences yet: on the one hand (5) they are lacking experiences with planning of lessons - since they are still at university - and on the other hand the students have not had many experiences with problem-solving or inquiry-based learning themselves (5). In the reflection one student wrote with regard to the questionnaire he/she filled out at the beginning of the course that he/she "presumably answered the questions like someone who does not study chemistry, probably because I have come in contact with chemistry during my studies, but not with the approach of a researcher" (Portfolio ET). The teacher students didn't necessarily relate this with the difficulties they felt during their planning, but this relation is worth to be considered in the future.

Despite the problems all the students appreciated the practical experience. As mentioned above a lot of them have not made a lot of practical experiences yet, so the preparation of the lab-day (the developing of learning material, designing and testing experiments and so forth) as well as the handling of (smaller groups of) pupils were perceived as a good testing situation and offered them support for their future as chemistry teachers:

> "I'm a bit anxious with pupils in the lab. To practice in a small group was the most valuable for me […]. It was good to be in the laboratory with pupils, to guide them and also this dialogue" (Interview AG)

CONCLUSIONS AND OUTLOOK

The course "Chemistry meets Chemistry Education" could successfully initiate reflection about the pre-conceptions teacher students have about chemistry and chemical research; all of the participants gained a more precise image about the subject they are studying. Moreover, this reflection is perceived as meaningful and important both for themselves as future teachers and for pupils as well. The transformation of the students' views into practical activities succeeds in part. As there are still some difficulties, the pre-service teachers need more support in designing authentic learning environments.

According to the overview of the project, the step from pre- to post-conceptions has been achieved with the two courses "Chemistry meets Chemistry Education". With the second course the way to identify practical-relevant elements is paved, but this step is not finished yet. The following step is going to be the alignment of the identified practical-relevant elements. As it turned out that the teacher students need more support in creating authentic learning environments, the long-term aim of this project is to develop a course for chemistry teacher education into which the practical-relevant elements are embedded, to give the students assistance with the transformation into practical activities.

ACKNOWLEDGMENTS

The author thanks the DAAD for their financial support.

NOTES

1. For example: (Aikenhead, 2004; Hoffmann & Torrence, 1993; Johnstone, 2010; Olmsted III, 2010)

2. Since no Anglo-Saxon equivalent of Mayring's analysis exists, this is the author's translation of his approach. Mayring refers to grounded theory, but describes his analysis as more systematized. Criteria for selecting categories are to be defined before the analysis out of theoretical considerations in regard to the object and aim of the study. Next the data is worked through; new categories are constructed if a passage matches the established criteria. Several rounds might be necessary; thereafter a category system is the result, which can then be interpreted in regard to the research question.

3. Letters represent anonymization, translation by the author.

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PRE-SERVICE IRISH SCIENCE TEACHERS' MISCONCEPTIONS OF CHEMISTRY

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Abstract: Science teachers in Ireland are prepared through either a concurrent model or a consecutive model of teacher training. The university involved in this study offers a concurrent model of science teacher training. Like many other pre-service science teachers and students of science worldwide, these students have many misconceptions in chemistry. It has been noted that this is, in the main, due to the abstract nature of the subject which requires learners to operate at a high cognitive level. The issue of misconceptions in chemistry is a significant issue for the quality of pre-service science teachers as they may leave their third level education without having ever had their misconceptions addressed. For an improvement in science education to occur teachers must be able to apply the findings of research into chemistry misconceptions, yet many pre-service chemistry teachers have numerous misconceptions themselves. The poor subject matter knowledge of these pre-service teachers is likely to lead to the transmission of misconceptions to their students. This study aims to investigate the number and type of chemistry misconceptions pre-service science teachers possess and whether these misconceptions are altered as they progress through their degree programme.

Keywords: Pre-service science teachers; Chemistry misconceptions; Science education; Subject Matter Knowledge

INTRODUCTION

The development of adequate subject matter knowledge (SMK) in pre-service teachers is one of the main goals of teacher education programmes. Teachers must have sufficient knowledge to be able to understand the underlying structures and organisation of a subject (Shulman 1986). Misconceptions in chemistry have been widely reported in international literature (Mulford and Robinson 2002; Tan and Taber 2009). They are known to be deeply rooted, resistant to change (Mulford and Robinson 2002) and their presence can interfere with new learning (Clement 1982). In order to address this problem, teachers must be prepared to directly address these misconceptions. Teachers' SMK must be sufficient such that teachers have a sound understanding of the subject and hold relatively few misconceptions themselves (Shulman 1986). The pedagogical content knowledge (PCK) of science teachers must also include knowledge of common misconceptions, which they may expect to find in their students, and strategies to reduce these misconceptions (Shulman 1986).

BACKGROUND & CONTEXT

Prospective science teachers in Ireland are prepared through either the concurrent or consecutive model. The concurrent model involves a four year degree programme in science, pedagogy and education. In the consecutive model, graduates of science complete a Postgraduate Diploma in Education. The university involved in this study offers a concurrent model of science teacher education. The mode of science instruction is a traditional lecture style, which has been found to emphasise lower order cognitive skills such as recall (Zoller 1993), and may result in inadequate pre-service teachers' SMK. The SMK of teachers has been shown to have a significant effect on teachers' ability to plan lessons, use appropriate representations and detect the misconceptions of their students. Teachers with under-developed SMK are more likely to include misconceptions in lesson plans and use inaccurate representations which reinforce these misconceptions (Hashweh 1987).

During the spring semester 2010, the results of an exploratory study involving third year pre-service teachers suggested that a number of chemistry misconceptions, particularly in the area of the particulate nature of matter (PNM), were present. A larger scale pilot study including pre-service teachers from all four years of study was then carried out. The research questions guiding this study were:

1. What chemistry misconceptions do these pre-service science teachers hold?
2. Is there a link between these misconceptions and gender, age, previous school experience of mathematics and chemistry or pre-service teachers' chosen course of study?
3. Are the misconceptions present in the first year of pre-service teachers' concurrent programme altered over the course of four years of formal study?

METHODOLOGY

Participants in this study were required to complete a pencil-and-paper instrument designed to assess for the presence of misconceptions in chemistry.

Table 1: List of Concepts & Questions included in the Instrument

Concept Area	Subtopic (where relevant)	Question No.	Concept(s) being tested	Source of Questions
Particulate Nature of Matter	Atomic Structure	Q7	Factors influencing ionisation energies	Taber (2003); Tan & Taber (2009)
	Chemical Formulae & Equations	Q5, Q6, Q11	Meaningful conversions from symbolic to microscopic	Mulford & Robinson (2002)
	Phase Change	Q3	Understanding of phase change	Yezierski & Birk (2006); Sheehan (2010)
	Conservation	Q4	Conservation of matter	Mulford & Robinson (2002)
	Composition of Matter	Q1, Q2	Microscopic nature matter	Sanger (2000); Mulford & Robinson (2002)
Mole Concept		Q8, Q9, Q10, Q12	The mole as a counting unit, use in stoichiometry and molar volumes	Sheehan (2010); Claesgens & Stacy (2003)
Chemical Bonding		Q13, Q14, Q15, Q16, Q20	Process and energetics of bonding, effect of bond type and structure of ionic compounds	Peterson & Treagust (1989); Mulford & Robinson (2002)
Equilibrium		Q17, Q18	Dynamic nature of equilibrium and the equilibrium constant	Krause *et al*. (2004); JCE website

Chemistry misconceptions and concepts related to the Leaving Certificate syllabus were identified based on the literature. The resulting instrument, described in Table 1, was composed of 23 questions and reviewed by experts. It was administered to each year group of pre-service teachers expected to receive a qualification to teach science. A response rate of 77% (212 participants) was achieved. Responses were analysed using PASW.

RESULTS

The percentage of first, second, third and fourth year pre-service teachers in each grade band are shown in Figure 1. The majority of pre-service teachers (>80%) achieved less than 40%.

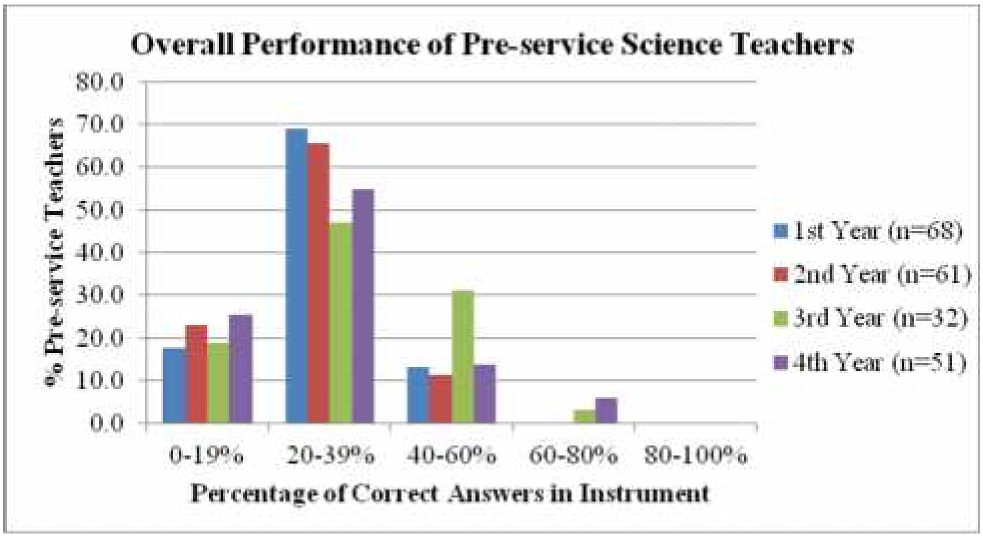

Figure 1: Performance of Pre-service Teachers in Instrument

Table 2 shows the average score for the entire sample group of 212 for each conceptual area included on the instrument. Pre-service science teachers displayed poor understanding of all the conceptual areas in the instrument, with PNM being the most poorly understood area.

Table 2: Breakdown of Mean Scores for Each Conceptual Area in Instrument

Concept Area	Questions	Average Score (n=212)	% of Sample not Attempting Section
Particulate Nature of Matter	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q11	28.2%	0
Stoichiometry	Q8, Q9, Q10, Q12	43.0%	0.5
Chemical Bonding	Q13, Q14, Q15, Q16, Q20	32.7%	1.4
Equilibrium	Q17, Q18	31.1%	0.9
All Areas		30.8%	0

In the pre-service teachers' responses, a number of significant factors emerged as having an effect on their performance. The year of study had no significant effect on their performance. A summary of the statistical tests performed may be found in Table 4. Figure 2 shows the performance of each year group for each question in the instrument. Nine questions were answered correctly by less 20% of the total cohort, with five questions related to PNM and two to chemical bonding. The highest number of misconceptions was in the PNM. Common misconceptions were a failure to conserve atoms (74.9%) and confusing the meaning of subscripts and coefficients (56.5%). Table 3 provides a list of the misconceptions.

Table 3: List of Specific Misconceptions found in more than 10% of Pre-service Teachers

Concept Area	Subtopic (where relevant)	Misconceptions Identified	% of Sample (N=212)
Particulate Nature of Matter	Atomic Structure	Use of Octet Rule analogy to explain differences in ionisation energies	42.0%
		Use of relation-based reasoning to explain differences in ionisation energies	34.4%
	Chemical Formulae & Equations	Confusing the meaning of coefficients and subscripts	56.5%
		A failure to conserve atoms or understand the role of a limiting reagent	74.9%
	Phase Change	A belief that a phase change from liquid to gas involves the breaking of covalent bonds	30.1%
	Conservation	Matter not conserved as gas weighs less or is less dense than solid	27.8%
	Composition of Matter	Attributing macroscopic properties such as density, melting point and structure to a single atom	52.4%
		Identifying all pure substances composed of elements as homogeneous mixtures	20.7%
		Identifying pure substances composed of compounds as heterogeneous mixtures	25.5%
		Identifying substances containing more than one element as compounds	30.2%
Stoichiometry	The Mole	The mass of a particle affects the number of particles in one mole of substance	31.1%
		The type of particles affects the number of particles in one mole of substance	10.4%
		12g of Carbon contains a mole of electrons	58.0%
		Unable to apply mole ratio to generic chemical equation	30.2%
	Volumetric Analysis	Belief that a solution of 1M contains molecular mass of substance in 1 L of water	19.8%
Chemical Bonding		Belief that an ionic bond involves the sharing of electrons	15.6%
		The electron pair is centrally located in a covalent bond	30.2%
		Breaking bonds releases energy	61.1%
		Ionic bonding is always stronger than covalent bonding	19.3%
		The presence of metallic bonds raises the boiling point of a substance	12.7%
		N_2H_4 is a resonance structure	15.6%
		Lone pairs can never exist on adjacent atoms	16.5%
		Nitrogen forms triple bonds when possible	26.9%
Equilibrium		Reactant concentration increases as equilibrium is established	28.8%
		Concentration fluctuates as equilibrium is established	20.3%
		Failure to understanding meaning of equilibrium constant	49.0%

Table 4: Significance of Relationships in the Study

Relationship being Tested	Statistical Test(s)	Result	Meaning
Gender & Overall Score on CMII	Independent Samples T-Test	t(210) = -4.43, p < 0.05	On average, male participants (M = 35.7, SE = 1.5) achieved higher scores than female participants (M = 28.1, SE = 0.96).
Age & Overall Score on CMII	Bivariate Correlation	r = 0.153, p < 0.05	Older pre-service teachers were found to achieve significantly higher scores.
Course of Study & Overall Score	One-Way ANOVA Hochberg Post-Hoc Test	F(5, 206)=8.29, p<0.05	The mean score for those studying '*Physical Sciences (ed)* (M = 44.2, SE = 2.6)' was significantly greater than those studying '*Biological Sciences with Chemistry Elective* (M = 29.4, SE = 1.8).
Leaving Certificate Chemistry Level & Overall Score	One-Way ANOVA Hochberg Post-Hoc Test	F(2, 171)=7.58, p<0.05	Pre-service teachers with higher level chemistry for the Leaving Certificate (M = 33.5, SE = 1.1) achieved higher scores than those that did not study chemistry for the Leaving Certificate (M = 25.5, SE = 1.7).
Leaving Certificate Mathematics Level and Overall Score	Independent Samples T-Test	t(204)= -3.30, p<0.05	Those that studied higher level mathematics (M = 33.4, SE = 1.2) for the Leaving Certificate achieved higher scores than those that studied ordinary level mathematics (M = 27.8, SE = 1.2).
Year of Study & Overall Score	One-Way ANOVA Gabriel Post-Hoc	F(3, 208)=1.79, p>0.05	Those in their fourth year of study achieved the same scores as those in their first, second and third years of study

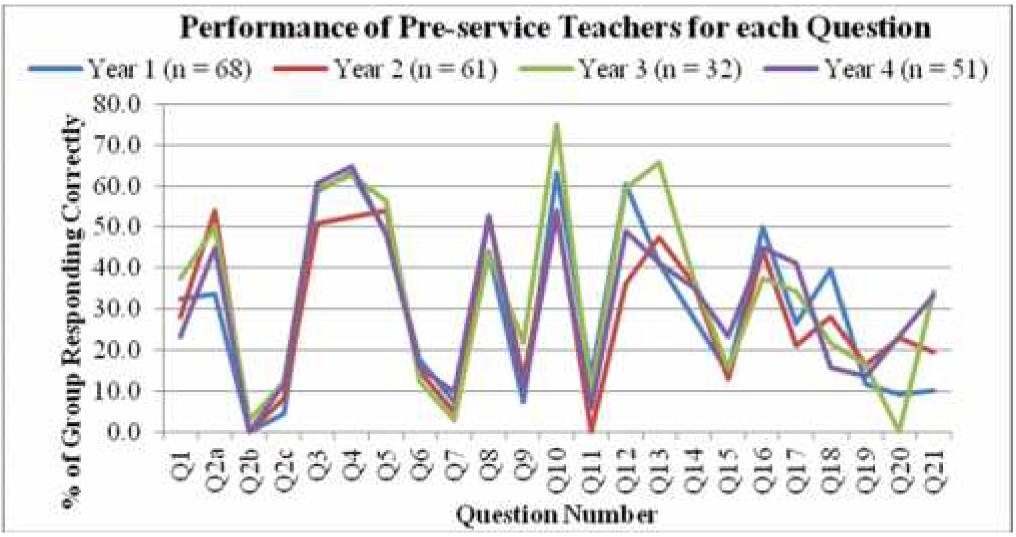

Figure 2: Breakdown of Performance of Pre-service Teachers for each Question

DISCUSSION

The number of misconceptions found among pre-service science teachers in the overall study was high with over 80% achieving less than 40% in the test instrument. The average overall score was 30.8%. Other studies, which have looked at the understanding of general chemistry concepts, have resulted in similar findings. Mulford and Robinson (2002) noted that the average score achieved by college students was 45.5%. In Ireland, Sheehan (2010) found that the majority of Junior Certificate (67.2%) and Leaving Certificate (63.8%) pupils achieved less than 40% in a chemistry concepts test. Direct comparison cannot be made between this study and our study, given that different instruments were used. However, both studies indicate that throughout secondary and tertiary level education in Ireland the number of misconceptions held by learners remains unacceptably high, and is little affected by additional years of study.

Gender, age and course of study had a significant impact on the number of misconceptions held: with pre-service teachers who were male, over twenty-one years of age and specialising in the physical sciences holding fewer misconceptions. The differences associated with these groups may be the result of higher cognitive levels. Male students at university level are more likely to operate at the formal operational level (Sheehan 2010) and Shayer and Adey (1981) noted a direct correlation between cognitive development and age. Those on the physical sciences course were more likely to have studied Higher Level mathematics for the Leaving Certificate and may have had a higher mathematical ability. A positive correlation has also been shown between mathematical ability and cognitive level (Sheehan 2010).

Pre-service science teachers demonstrated the poorest conceptual understanding in questions related to PNM (M=28.2%). Over 60% achieved less than 40% in this area. Yezierski and Birk (2006) note a similarly poor understanding of this conceptual area among college general chemistry students. The number of misconceptions held by pre-service teachers about PNM appear similar the number held by Junior and Leaving Certificate pupils (Sheehan 2010).

Possibly the most significant finding of this study is that there was no trend or significant relationship between the year of study and the number of misconceptions held by pre-service science teachers. In the vast majority of questions, there was also no relationship between the year of study and the responses selected. This suggests that neither the number nor type of misconception is significantly altered over the course of four years of the concurrent teacher training programme.

The results of this study indicate that the SMK of pre-service teachers in this particular university is weak. Participants demonstrated the poorest understanding in concepts related to the PNM which may be considered to be the foundation upon which all other conceptual areas in chemistry are built. The lack of understanding found in this fundamental area suggests that it is unlikely that these pre-service teachers understand the structure and organisation of their subject. As previously mentioned, a weak SMK and high levels of misconceptions may lead to these pre-service teachers creating lesson plans which include misconceptions, presenting inaccurate representations, reinforcing misconceptions and being unable to detect misconceptions among their pupils (Hashweh 1987).

CONCLUSIONS & IMPLICATIONS

The limitations of this study included its semi-longitudinal nature which merely provides a snapshot of the heterogeneous groups in each year of study. The results indicate that pre-service science teachers taking part in the study have unacceptably high levels of chemistry misconceptions across all years of study. These misconceptions are not reduced or altered in any significant way over the course of four years of study. This suggests that the concurrent science education programmes at this university are not successful in addressing pre-service teachers' misconceptions or deepening their understanding of chemistry concepts.

It is, therefore, producing teachers with weak SMK. Given their own lack of understanding of the subject, it seems unlikely that the PCK of these pre-service teachers is sufficient to allow them to identify and address the misconceptions of their students. The results of this study, in combination with the study performed by Sheehan (2010), suggest that the education system in Ireland is not successful in the reduction or alteration of chemistry misconceptions in learners. The concurrent programmes at this university would seem to be producing teachers that may only prove to worsen this state of affairs. This is a situation that clearly needs to be addressed.

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STUDENT-TEACHERS' PARTICIPATION IN THE DEVELOPMENT OF DIGITAL STORIES FOR THE MOON AND THE TELESCOPE

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Abstract: The focus of this paper is on how narrative forms of science learning material can be introduced in teacher education courses. Particularly the participation of two student-teachers in the development of two stories about the moon and the telescopes is explored. Historic and media information has been identified by one of the student-teachers in order to develop the storyboards of the scenario, while the technical and connective aspects of creating the digital form have been considered by the second. The development of the story scenario to narrate how the discovery of telescope and Galileo contributed to scientific development and how today the research about the moon has advanced was a demanding task. Evidence showed that the final learning digital products have been created through an intensive collaborative scheme in order to support student-teachers' difficulties at the conceptual and structural level. Implementation of the final products in classrooms reveals the potentiality of digital storytelling and also aspects that need to be considered for an effective science learning narration.

Keywords: Narrative forms of learning, Digital teaching stories, Nature & history of science, Collaborative teacher education, Authenticity in science teaching materials

INTRODUCTION

The quest of challenging environments for learning science is today an important goal of science education (Rocard et al, 2007), and is driven by the "sense of growing disparity between the science education provided in our schools and the needs and interests of the young people who will be our future citizens" (Millar & Osborne, 1998). The interwoven of science, pedagogy and technology (ICT) is desirable and is the focus of a number of research efforts (Web & Cox, 2004). In their extended review, Web & Cox conclude that reviewed research evidence suggests that teachers need to plan the focus of the assignment carefully and to provide appropriate materials that relate to the affordances of the multimedia composition experience and their teaching objectives. Doyle (2000) sees value in promoting versions of authenticity; he cautions that because school cannot be the real world, all content must be interpreted for teaching and the role of the teacher is to transform the subject matter into forms that represent authentic meaning to the child. One version of authenticity concerns the subject matter authenticity, in which the learning is designed to align with the work of professionals in the discipline (e.g. scientists) and for which the enemy is predigested versions of content in textbooks. Two ideas could enhance the development of authentic learning experiences: the invention of meaningful science learning stories and the utilization of digital storytelling. The inclusion of such ideas in teacher education and the case of two student-teachers' efforts to produce teaching multimedia material is described in this study.

RATIONALE

According to the Model of Educational Reconstruction (Duit, Gropengießer, & Kattmann, 2005), the content structure of a certain domain has to be transformed into a content structure *for* instruction, as the two structures are substantially different. Such a transformation today, however, can better take place taking into account pedagogical and technological considerations and utilities and teachers need to be prepared to act in such a frame. New technology can provide access to a wide range of information sources and is able to represent that information in a variety of forms - text, images & sound - for analysis and communication. Godfrey (2001) stresses the potential of ICT to present rich learning environments, allowing learners to adopt multiple perspectives on complex phenomena, to foster flexible knowledge construction in complex learning domains, and to cater for individual differences. Such representational forms of knowledge could also serve pedagogical approaches and curricular designs that integrate the sociohistorical understanding of science. The ‘stories’, which science tells about the material world and how it behaves, have made an enormous contribution to our culture (Fensham, 2001). Storytelling is considered as the original form of teaching (Pedersen, 1995).

Millar & Osborne (2000) argued that “science education should make much greater use of one of the world’s most powerful and pervasive ways of communicating ideas – the narrative form – by recognising that its central aim is to present a series of ‘explanatory stories’”, (p.2013). Although storytelling is not new, the idea of digital storytelling is new (Meadows, 2003). Within the last 10 years, digital cameras, editing software, authoring tools and electronic media outlets have encouraged teachers to utilize many more approaches and tools than ever before, to help students to construct their own knowledge and ideas to present and share them more effectively (Standley, 2003). One of these powerful approaches to multimedia production is digital storytelling. As the name implies, digital stories usually contain some mixture of computer-based images, text, recorded audio narration, video clips and/or music.

It is important for teachers to realize that stories of science told in classrooms could offer some understanding of where ideas exposed have come from. Moreover, benefits of using historical materials in primary science education have been recorded, while selecting and preparing historical source materials in digital format has been reported as a useful source of learning primary science (Kafai & Gilliland-Swetland, 2001). However, introducing such type of innovations in teacher education in order student-teachers to be able to develop their own materials is a demanding task. A ‘lesson study’ model (Hart, Alston & Murata, 2011) offers a possible model for teacher education. It places teacher at the center of the professional activity with their interest and a desire to better understand student learning based on their own teaching activities. Two distinct features characterize this model: lesson study has a research lesson and lesson study is collaborative. These ideas have been applied in two different teacher education courses. The study of student-teachers’ participation in the development and implementation of narrative learning materials was one of the goals of the efforts reported in this study. In this context the following research questions are posed: How can student-teachers be enhanced in participating in collaborative activities for the developmental and implementation of learning material? What does collaboration mean in such a frame? What kind of materials can be produced and which are their characteristics?

METHODOLOGY

The present research effort takes place in two different contexts of prospective teacher education contexts, the structure and philosophy of which follows a “design research” approach (Wood and Berry, 2003). It is also based on the ‘lesson study’ model (Hart, Alston & Murata, 2011). It also draws on Jaworsky’ s (2003) theoretical framework, which can be applied to analyse research projects involving multilayered research into teaching and teaching development in order to understand better the processes and practices involved, and the impact and outcomes of the research. The units of analysis are aspects and actions of the collaborative team that consists of two student-teachers and the educator/researcher. The focus is mainly on how two student-teachers' of different courses organized and taught by the educator/researcher, developed while working their final assignments on the development of teaching material on a topic concerned the moon, the scientists and the telescope. The first was a primary education student-teacher (Diana), who was involved in the project for a year, part of her degree thesis and after having attended a science education course for a semester. She designed and applied a detailed teaching intervention in a primary classroom. The second was a graduate of Informatics (Gregory), who attended a yearlong teacher education course, and simultaneously was part time teacher of basic ideas of informatics in primary education. He participated mainly in the production of digital teaching materials using the software Microsoft Photo Story 3 and he tried the final products with his primary students. Diaries of the meetings, the electronic communication, material collected and final products of this collaboration, videos and reports of the implementation in classrooms are the data of this study.

RESULTS

Student-teachers' involvement

The two student-teachers were enthusiastic while working on the project; they had a productive collaboration and worked hard. Two goals were initially posed for their work: to create a narration for the moon and the telescope and to utilize multimodal representational forms for the storytelling. The epistemic goal was, through their own involvement in the creation of teaching material and lessons, the development of students' awareness of the ways people have gained knowledge about the moon, of the value of instruments like the telescope and of how scientific knowledge and research methods changed over the time.

The main idea was the development of narrations for revealing the value of the invention of a scientific tool like telescope to primary students of 6^{th} grade. Historic persons' inventions, the role played by the sociohistorical environment, the real facts of science development are considered ideas that can attract and help students to appreciate the old and new approaches in the research about the moon. The actual adoption of these ideas by the student-teachers cannot be considered as given. Diana started to work on producing teaching material for the moon:

- She reviewed students' ideas about the astronomical concepts.
- She herself was informed and learned more about the science of the moon and produced a body of core concepts related to the primary teaching of moon.
- She studied appropriate bibliography and became aware of using history of science with students and of epistemic goals.
- She identified historical material both textual and visual.
- She finally tried to prepare a scenario for the moon and the telescope, and to present the narration in a PowerPoint form (the storyboard).

This storyboard would function as the basis board for the final digital narration. Diana was skeptical for the appropriateness of historical materials for primary students. Although she collected a number of interesting historic electronic materials, she was unable to understand their meaning and met difficulties in designing any form of narration. At this phase, the support of the educator was crucial in order the scenario to be produced.

Gregory developed the digital photo stories giving emphasis on artistic features selected successfully the music background and the narration of the story added his own images altering sometimes the desired meanings by emphasizing his choices, which aimed more the grace of narration than the revelation of the actual historical and conceptual aspects of the subject to be taught. Gregory, based on the already produced scenarios, developed the digital photo stories giving emphasis on technical and artistic features.

The two student-teachers cooperated in both the development of the video and the evaluation of classroom implementation. They both admitted how difficult but valuable the process of developing narrative teaching materials and digital Photo Stories is. Throughout this collaborative activity student-teachers expressed feelings initially of weakness to complete this task and to apply in classrooms, but finally satisfaction with the results and a degree of awareness of what such a digital teaching material means. All three participants of the lesson study team gained valuable experience throughout the lesson study collaboration and also during the classroom implementation.

Products

The initial plan was to produce one narrative teaching story. Through collaboration during the lesson study the initial narration broke finally to two scenarios and subsequently two storyboards have been produced. These were the basis for the development of the two final digital products, the videos. Parts of the created storyboards are presented in figures 1 and 2. The first story (fig. 1) describes the bombardment of the moon at 2009 and the discovery of water ice at the lunar South Pole. It ends by saying that at the old times people used other ways to learn about moon.

Fig. 1 The first scenario: the beginning of the storyboard

The second story narrates the invention of telescope, the role of scientists of this era and particularly of Galileo and the social obstacles he met when stated his arguments (fig. 2). It ends by stating that Galileo's ideas had been finally accepted and established in Newton's era. Scenes of Galileo's demonstration of the telescope to the senate and the Doge and later of his prosecution by the Inquisition are also involved.

Initial options during the process of scenario development have reconsidered and changed by the team. For example, instead of the astronaut of the last scene in Figure 1, a piece of information found by Diana, a young scientist in normal clothes sat in his lab desk was presented, while his words for the experiment were narrated. The young scientist's portrait and explanations had been found by Gregory after educators' suggestion to cross-check the details of the experimental procedure of NASA. This change was decided in order to highlight that scientists today are everyday people working on a specific scientific plan which includes a carefully designed bombardment of the moon, but also analysis of the vapor clouds guided from a computer lab in NASA.

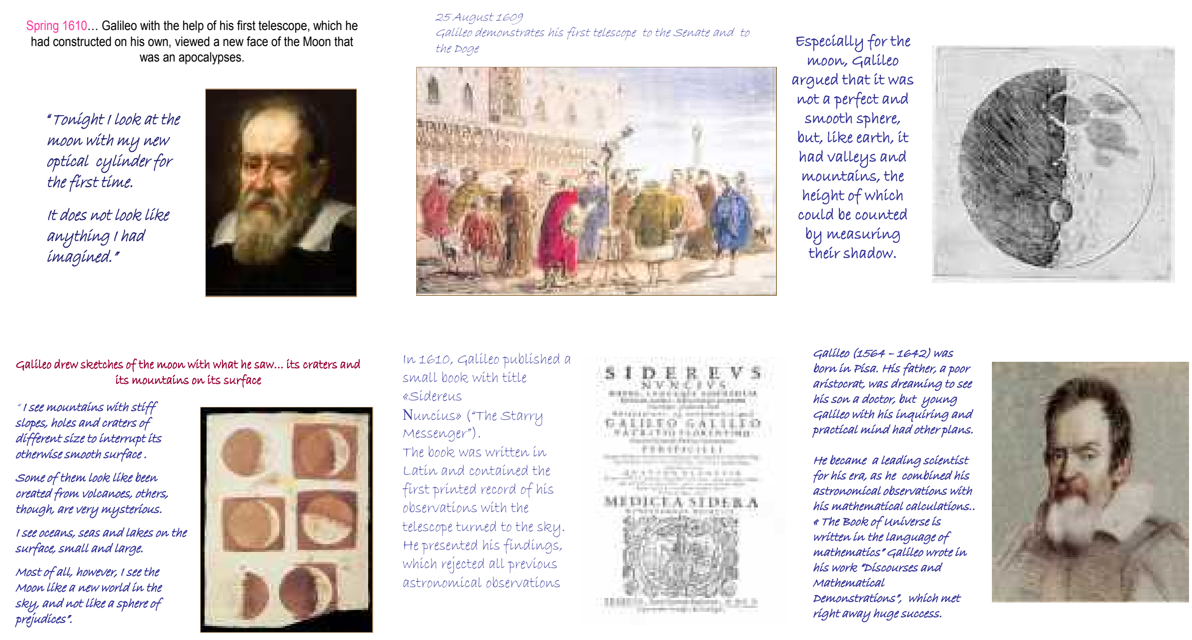

Fig. 2 The second scenario: Galileo episode

Classroom Implementation

The implementation of videos in primary classrooms by the student-teachers provided evidence of their function with the students, and offered to student-teachers the chance to integrate their lesson study experience. It, also, revealed how secondary narrative features of the stories attracted students' attention unintentionally.

Diana organized a lesson in a sixth grade classroom based on the two videos. An intervention with a number of tasks for the students before and after the play of the video was designed. 16 students participated in the intervention that lasted two hours. The analysis of data collected during the teaching implementation provided evidence of positive outcomes in many ways. Videos stimulated students' interest, supported their understanding of the content and context of the presented conceptual field and developed their awareness of how science develops and scientists work. Students' responses revealed a shift in the way they talked about the moon and the scientists from a general level to more specific issues, which the videos included. For example, more students talked after they attended the videos for the moon as satellite, the mission of LCross, the mountains and the valleys on the moon. They also talked more specifically for the telescopes and Galileo's life and role, while all of them referred the existence of water on the moon, fact that only few students knew at the beginning. Gregory used the videos in a freer way, but he also reported positive outcomes in terms of students' response to this experience similar to Diana's findings.

During the second scenario, where the story's duration was longer, students' interest and attention appeared to be decreased towards the end of the story. It seems that the balance in the use of historical details is crucial. It is worth mentioning the fact, that secondary narrative tricky features of the stories, like a reference to strange figures (one scene with the shape of the rabbit on the surface of the moon) that people many years ago believed to see at the moon affected students' perceptions.

Collaborative actions

Analysing the collaborative experience during the lesson study a number of actions have been identified: *actions between two members*, *common actions*. In terms of actions between two, we can distinguish between *querying actions* and *co-working in pairs*, while in terms of common actions we can distinguish *team work/decision making* and *sharing experiences*. For example, when Diana sent a mail to the educator asking how to proceed, it is a collaborative action between two and is characterized as a querying action. When Diana or Gregory communicated with the educator or between themselves to work together, this is characterize as working in pairs. Meetings with all three members of the team is meant to be a common action and when the discussion was around the story and its unfoldment, this is considered as team work/decision making. Finally, attending Diana's lesson and discussing about the students' understanding is considered as a common action with sharing experiences.

CONCLUSIONS

Aspects like authenticity, nature and history of science, narration of science stories, digital storytelling are important and challenging ideas to be involved in teacher education courses of science education and educational technology. These seem to obtain meaning and be possible only when student-teachers participate in projects aiming to develop innovative teaching materials that can be created through collaborative process. The lesson study model incorporates aspects like the development of research lesson, where teachers plan and implement the teaching materials like being researchers themselves. Another aspect is related to the fact that participants work both independently and collaboratively. It can be concluded that the particular factors of the student lesson cycle provided greater opportunity for the student-teachers to increase their knowledge for developing teaching innovative materials, for planning and implementing teaching interventions.

Our experiences working in the lesson study team show that student-teachers are able to initiate a lesson inquiry, by collecting information or by using technological tools, but they meet difficulties in building meaningful stories of the scientific endeavor, both at the conceptual and the technical levels. They are able to recognize the value of such narrations, but they feel uncertain with the inclusion of such teaching stories in classroom implementation. Collaborative approaches, between students and educators in the context of teacher education courses, offer valuable experiences to all participants and also opportunities for interesting and meaningful learning materials to be produced.

Four important factors have been identified and can be suggested as crucial for the production of the narrations and the teaching videos:

- the information and materials collected (real stories, visual representations, authentic sources),
- the development of the script scenario in order to attain the teaching goals, especially the epistemic ones,
- the selection and synthesis of the textual, visual and audio elements during the construction of the digital Photo Story, and
- the balance between images, narration, textual information on images and time spent in each screen.

Science stories help to frame the discourses of the school science classroom and different types of science stories told in science textbooks present implicit notions about the nature of science to teachers and students (Milne, 1998). The production of digital narrations is a complex task, but offers freedom to the designers to create a science story that will be 'politically correct' (Milne, 1998). This means that the contribution of people in science is presented more fairly and the interaction between science and society is examined critically giving the sense that they construct each other, as it happens in the second video produced in this study. Teachers need to be aware of the power of stories, and in producing meaningful stories collaborative schemes of work, like the lesson study, have a crucial role to play in teacher education and teacher development.

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PRE-SERVICE TEACHERS' CONCEPTUAL PROFILE CHANGE WHEN DISCUSSING AN ENVIRONMENTAL PHENOMENON

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Abstract: This study refers to distinguishing conceptual profiles in pre-service teachers' predictions and/or explanations about acid rain interaction with the natural environment. The way pre-service teachers make deductions about, and explain natural environment affection by acid rain is used as a case study topic in order to evaluate prospective teachers' ability to use scientific discourse when explaining environmental problems. In the course of a didactical intervention pre-service teachers were given the chance to interact with models of systems belonging to different scales through research-based-developed tools. The predictions and/or explanations pre-service teachers gave to the acid rain /environment interaction problem before, during and after the intervention were analyzed and five characteristic conceptual profiles were established.

Keywords: conceptual profile change, pre-service teachers, acid rain

INTRODUCTION

This study refers to distinguishing conceptual profiles in pre-service teachers' (students) predictions-explanations about acid rain interaction with the natural environment.
The study is based on a social constructivist perspective on learning (Leach & Scott 2005) according to which, science (as well as school science) is a social language providing the experts (or the students) with ways of talking and thinking about the natural world and thus explaining it. Students come to the science class bringing their own "everyday language" that has evolved in their social lives through normal day-to-day interactions. Students' acquisition of science language in the class plane is intermediated by their everyday language. Based on this social constructivist tradition, Mortimer (1995) suggested the notion of 'conceptual profile'. That means that it is possible for students to use different ways of thinking in different domains and that a new concept does not necessarily replace previous and alternative ideas, but everyday and scientific concepts may coexist. Even in the science classroom there may exist different conceptual profiles that indicate a movement from everyday language to school science language and these profiles have emerged as the result of the dialogue between these two languages. All these characteristic ways of thinking are "acceptable" and depict the conceptual evolution in the classroom. Research has shown that although high school students and in-service teachers try to use school science language to explain environmental phenomena they fail to reach scientific discourse which construes the world as consisting of hierarchically organized systems at different scales (Gunckel *et al* 2010, Anderson 2010). This study occurred in the context of a broader research studying how pre-service teachers explain

environmental phenomena using different scales' systems and processes. More precisely, the research questions are: a) what are the pre-service teachers' conceptual profiles when interpreting the acid rain natural environment interaction? b) How do these conceptual profiles change when interacting with models and systems belonging to multiple different scales?

METHODOLOGY

The acidic water / weathered bedrock reaction beneath soil is of great importance in the way acid rain affects the natural environment. Calcareous soil neutralizes acidity thus protecting surface waters and terrestrial ecosystems while siliceous soils are gradually acidified, in a time frame of some decades, and similarly are the waters on such watersheds (JCE, 2003).
In the context of a three - stage didactical intervention (fig. 1), pre-service teachers tried acid rain / environment interaction on different scales. They tried different materials' -mainly siliceous and calcareous- interactions with acids and bases in the wet lab. They tried "building" ecosystems lying on different bedrocks and zoomed into the micro-scale systems through research-based-developed educational software in the computer lab.
The didactical intervention was implemented in the academic year 2008-2009 with 59 pre-service teachers attending an environmental course at a pedagogical University in Greece. Pre-service teachers' descriptions and explanations about the acid rain / environment interaction recorded in worksheets during the didactical intervention, as well as pre and post tests filled in before and after the intervention formed the data source of the research (fig. 1).

Fig 1: Data collection during intervention

Initially, the data were analyzed and quantified regarding the way students use different scales' processes by means of a system of three categories ("Levels", "Kind of Change", "Effects on Ecosystems") containing 4-6 subcategories each. This analysis results have been presented elsewhere (Stoumpa *et al*, 2010).
Afterwards, the whole of the quantified data was revised in order to distinguish if characteristic patterns can be derived in the way pre-service teachers understand and describe the phenomenon. That is, if it is possible to distinguish different conceptual profiles that are

characteristic and representative for the pre-service teachers' conceptual evolution through their contact with different scales' systems during the didactical intervention. Thus, the overall category "Phenomenon Description" was constructed. As it is plausible, pre-service teachers change conceptual profile during the didactical intervention and even after it. Finally, five characteristic types of "Phenomenon Description" (conceptual profiles) were established as described below:

Descriptions that correctly explain how acidic water reaction with stones and minerals beneath soil prevents (or isn't enough to prevent) acidification, thus protecting aquatic and terrestrial ecosystems abiotic factors and life. This profile is called "**Sound Integrated**".

Descriptions that relate the reaction with the protection of ecosystems laying on calcareous subsoil, with some errors however, either because pre-service teachers think that this protection isn't universal, for example that this effect is restricted to aquatic ecosystems, or because they fail to provide a complete description of the reaction. This profile is called "**Transitional**".

Descriptions relating the strong acidic water / calcareous stones reaction to strong ecosystems erosion and/or considering that ecosystems lying on siliceous rocks are durable due to rocks durability. This profile is called "**Pragmatic**".

Descriptions that successfully describe the acid rain effects on ecosystems biota on calcareous (or siliceous) subsoil, but without any reference to the acidic water/weathered rocks and minerals reaction. This profile is called "**Phenomenistic**" which in Greek means clinging on just what is obvious.

Descriptions that fail to approach the phenomenon both in describing the ecosystems evolution under acidic affection and in giving a description of acid / stone reaction, even a simplistic one. These descriptions are characterized as "**Inadequate**".

RESULTS

In the following chart (fig 2) the conceptual profiles that where identified before, during and after the intervention are depicted:

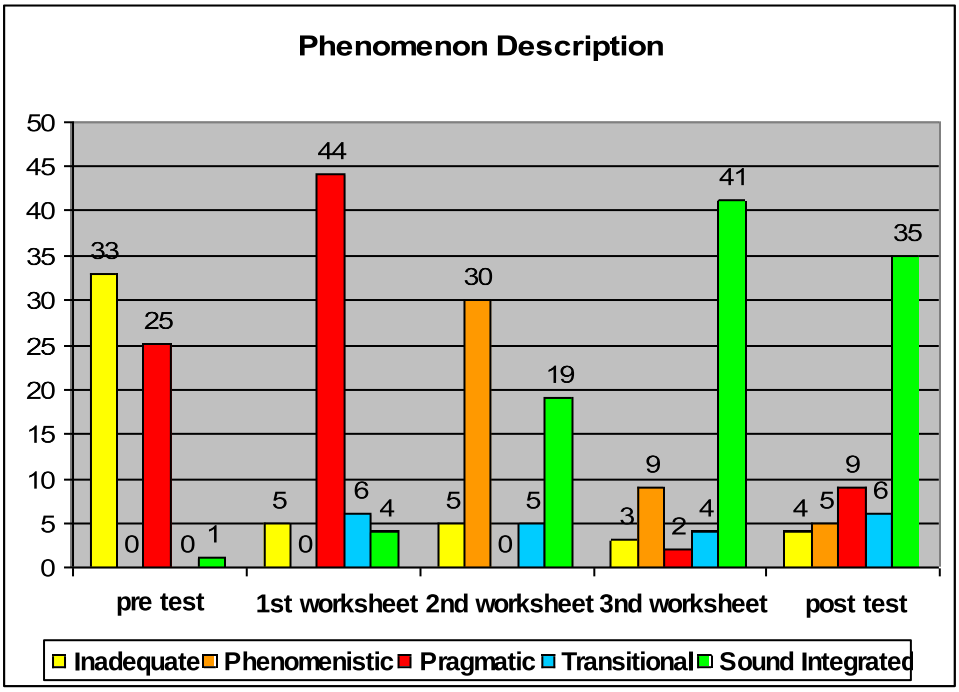

Fig 2: "Phenomenon Description": Conceptual profiles evolution during the intervention

Initially (in the pre test) pre-service teachers tended to consider the environmental phenomenon either making “Inadequate” predictions either superficially applying their knowledge about macroscopic phenomena to whole ecosystems (strong stone affection means strong ecosystem erosion).

In the wet lab (“macroscopic” approach) the pre-service teachers observed the damage acids cause to calcareous materials as well as the durability of siliceous ones. This encouraged them to deduce damage for ecosystems when the bedrock is calcareous, and durability when the bedrock is siliceous. So, the majority of them moved to “Pragmatic” descriptions. It is worth mentioning that all of them had taken measures about pH changes and recorded them down on their worksheets. However, a small but not insignificant proportion of them went ahead to “Transitional” and “Sound Integrated” descriptions.

The “Large scale” approach in the computer lab (ecosystems’ supervision) led a significant percentage of them to move on to “Transitional” and “Sound Integrated” descriptions in which pre-service teachers realized how the reaction protects soil and water by neutralizing acidity, thus protecting biota. However, those who failed to see this “good” side of the reaction preferred to ignore it and gave “Phenomenistic” descriptions.

The introduction of the microscopic (atomic/molecular) systems in the third stage of the intervention led the majority of them to “correctly” and more sophisticatedly understand the macroscopic processes and helped them to “successfully” relate the chemical interactions with abiotic factors’ properties and the corresponding consequences to the aquatic and terrestrial life.

CONCLUSION AND IMPLICATIONS

As the results suggest, the microscopic approach, in the end of the didactic intervention, significantly enhances the ability of pre-service teachers to form "Sound Integrated" descriptions and explanations of the problem they studied. However, it was the whole approaching in different scales that helped them to gradually familiarize with the science language. So, student -teachers' interaction with natural world phenomena on different scales, significantly contributes to their ability to understand the development of phenomena taking place in too large time and space scales to be directly observed, as well as the mechanisms underlying and explaining this development.

Since environmental phenomena and problems are large-scale ones, it seems that such interactions can enhance environmental science literacy, meaning the pre-service teachers’ ability to understand and participate in evidence-based discussions of environmental problems or critical environmental issues. Consequently, it is recommended that teaching materials be created, giving pre-service teachers the chance to try and observe systems that are too small or too large to be directly perceived. This is in accordance with other researchers’ studies suggesting that research-based didactic material and didactic interventions development may lead to students reaching (or at least approaching) scientific discourse reasoning (Anderson 2010, Mohan & Anderson 2009).

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VIEWS ON TEACHING OF PARTICULATE NATURE OF MATTER AT MACROSCOPIC, SYMBOLIC AND MICROSCOPIC LEVELS

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Abstract: Establishing conceptual relationships among macroscopic, symbolic, and microscopic levels is important in chemistry teaching and learning. The aim of this study was to investigate how pre-service chemistry teachers use macroscopic, symbolic, and microscopic levels and how they integrate teaching strategies with these three levels while teaching particulate nature of matter. Also, their opinions on the importance of using these levels in their instructions were examined. Eight pre-service chemistry teachers participated in this study. Three open-ended questions were administered to all participants at the beginning of practice teaching course. Then, three participants were interviewed to deeply analyze their responses. Written responses of question-2 were analyzed by researchers independently, then they came together to reach a consensus. Results indicated that pre-service chemistry teachers mostly preferred to use lecturing method at each level of chemistry in their instructions. Moreover, most of them had difficulties in using all levels and integrating these levels into teaching methods/strategies while teaching particulate nature of matter. However, they thought that using these three levels while teaching chemistry concepts is important in order to enhance student meaningful learning. Thus, teacher education programs should emphasize macroscopic, symbolic and microscopic levels, interactions among them, and how to use these levels in chemistry teaching.

Keywords: particulate nature of matter, macroscopic, symbolic, microscopic, pre-service chemistry teachers

BACKGROUND, FRAMEWORK, RATIONALE, AND PURPOSE

Establishing conceptual relationships among levels, which are macroscopic, symbolic, and microscopic, is important in order for students to meaningfully understand chemistry (Hinton & Nakhleh, 1999; Johnstone, 1993). The macroscopic level of chemistry is related to the observable phenomena such as burning a candle and color change. The symbolic level is represented using pictorial, algebraic, physical, and computational shapes. At the microscopic level, burning candle becomes a chemical process and carbon atoms of the wax react with oxygen molecules in the air, thus carbon dioxide molecules are produced (Hinton & Nakhleh, 1999; Wu, 2003).

Research studies revealed that students could not correctly explain chemical concepts using these three levels (Hinton & Nakhleh, 1999; Pozo, 2001). Especially, they have difficulties in understanding chemistry topics at the symbolic and microscopic levels (Tsai, 1999; Wu, 2003). Reasons of these difficulties might be their poor understanding of nature of particles (Ben-Zvi, Eylon, & Silberstein, 1986; Williamson & Abraham, 1995), their incomplete or inappropriate mental models (Harrison & Treagust, 1996), and their poor connections between school science and real life experiences (Osborne & Freyberg, 1985 as cited in Wu, 2003).

Recent studies on pre-service teachers' use of three levels have shown that pre-service teachers explain chemistry concepts using the macroscopic level, but they cannot use the symbolic and microscopic levels during instruction. Moreover, they cannot create connection among these levels (Lee, 1999; Pozo, 2001). The purpose of this study was to investigate how pre-service chemistry teachers (PCTs) use the macroscopic, symbolic and microscopic levels, and how they integrate teaching strategies into these three levels while instructing particulate nature of matter (PNM). In addition, their opinions on the importance of using these three levels in their instructions were examined. Research questions of this study were as follows:

1. How do PCTs use the macroscopic, symbolic and microscopic levels while instructing PNM?
2. How do PCTs integrate teaching strategies into the macroscopic, symbolic and microscopic levels while instructing PNM?
3. What are the pre-service teachers' opinions on the importance of using the macroscopic, symbolic, and microscopic levels in their instructions?

METHODS

Eight PCTs, 3 males and 5 females, enrolled in practice teaching course in a state university in Turkey participated in the study. Three open-ended questions were administered to all participants at the beginning of the semester. Suggestions of six experts in chemistry education were taken into consideration about the open-ended questions. After the first teaching practice of participants in the high school and university, three of them were voluntarily interviewed to deeply analyze their responses to questions. Interviews were tape-recorded and lasted approximately 45 minutes. As this study investigated pre-service teachers' understanding on PNM at all levels, researchers examined only question-2 which is presented below:

"You are supposed to teach PNM to your students by integrating the macroscopic, symbolic and microscopic levels into your instruction.

a) What kind of teaching method(s)/strategies would you use? How would you design your instruction? Why?
b) How would you teach PNM concepts at each level?
c) Do you think that this kind of instruction affects your students' understanding of PNM? Why?"

Qualitative content analysis method (Creswell, 2009) was used to analyze the data. Firstly, responses of participants were analyzed independently by each researcher. During the data analysis, the researchers took into consideration whether the participants integrate the macroscopic, symbolic and microscopic levels into their instruction, and which teaching methods/strategies they used while teaching PNM at each level. Moreover, the researchers categorized the participants' opinions on the effects of using levels in their instructions on students' understanding of PNM. Then, all researchers came together and discussed the answers to reach a consensus on the answers. The names of the participants were coded as from PCT-1 to PCT-8. PCT-1, PCT-2, and PCT-3 were also interviewees in this study.

RESULTS

Results of the study indicated that PCTs mostly prefer to use lecturing method at each level of chemistry in their instructions. To teach PNM at the macroscopic level, PCT-2 and PCT-4 stated that they would use lecturing. For instance, in her written response, PCT-2 claimed that she would give chemical bonding concept at the macroscopic level as; *"I will give firstly the definition of these two concepts (ionic and covalent bonding) and I will give examples from daily life."* In the interview, she also confirmed to use lecturing at this level as; *"At macroscopic level I'll state what ionic compound is. I'll use lecturing and I'll relate sodium chloride with daily life by saying that sodium chloride is table salt."* On the other hand, PCT-1 used demonstration while teaching the void structure of matter at the macroscopic level and stated it as;

"I use demonstration to explain the void structure of matter. For example: ethyl alcohol + water mixture. Before the demonstration; I ask students what they expect to see or at the end of the demonstration I want them make prediction for the aim of experiment."

She also confirmed same ideas in the interview. PCT-6 preferred to use analogy. He stated that *"For the macroscopic level, I would use analogy which will make the understanding of the topic easy for students, for example, I may use solar system analogy for the Bohr's atomic model."* Other four participants did not state any method and also they did not teach PNM at this level.

To teach PNM at the symbolic level, PCT-1, PCT-2 and PCT-4 stated that they would use lecturing. For instance, PCT-4 explained how she would give the instruction on the topic of compounds at the symbolic level as; *"to present the symbolic form of the molecule, I would draw on the board that one oxygen atom is bonded to two hydrogen atoms to form a water molecule."* PCT-2 also wrote that *"I will write examples to the board by using Lewis dot structure and symbols of elements. I will show the occurrence of ionic and covalent bonding with correct arrows."* However, in the interview, she claimed that she would enrich her lecturing using questions related to the formation of compounds from elements to make students more active. Other five participants did not state any method for teaching PNM at this level. Although PCT-3 did not propose any method in her written responses, in the interview, she stated that she would use lecturing while teaching PNM at the symbolic level.

PCT-1, PCT-2 and PCT-4 stated that they would use lecturing to teach PNM at the microscopic level. All of them mentioned that they would use videos and animations to show the structure of matter at the microscopic level during their lecture. For instance, in her written response, PCT-2 explained this situation on the topic of ionic and covalent bonding as; *"I will use an animation or video to show students what happens at the microscopic level while these bonding occur."* Moreover, in the interview, she claimed that she would support lecturing using analogy to teach ionic bonding at the microscopic level. Other five participants did not state any method for teaching PNM at this level. Although PCT-3 did not mention any method in her written responses, in the interview, she claimed that she would use lecturing by supporting animations while teaching at the microscopic level as *"Just saying an element loses or gains electron while forming a compound is not sufficient. We also need to use animations to make them understand the concepts at the microscopic level."*

Finally, in both written responses and interview, most PCTs thought that teaching chemistry topics at three levels is important. They claimed that this kind of instruction has powerful effects on student learning since it provides meaningful learning by making concepts more concrete. In addition, they thought that it helps students to visualize the concepts; therefore, students do not try to memorize concepts. Moreover, they stated that learning in the microscopic level prevents students having misconceptions on the concepts. One of the participants explained this situation as following: *"When the instruction doesn't include the microscopic level, students could not be able to understand the concepts so these concepts should be made concrete."*

CONCLUSIONS AND IMPLICATIONS

The PCTs participated in the study thought that it was important to use these three levels while teaching chemistry concepts in order to enhance student meaningful learning. However, they had difficulties in using all levels and integrating these levels into teaching methods/ strategies while teaching PNM. Several studies in the literature support the findings of the present study (Bektas, Tuysuz, Ekiz, Uzuntiryaki, 2010; Pozo, 2001). Although all participants had taken teaching method courses, they only preferred lecturing method for all levels in their instructions. It is recommended that teacher education programs should emphasize the practical lessons regarding integration of levels to the different teaching methods in chemistry. Moreover, if representations and explanations at the symbolic, microscopic, and macroscopic levels are emphasized during teacher training programs, pre-service teachers' difficulties in using three levels can be overcome.

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CHEMISTRY TEACHERS' CONTENT KNOWLEDGE AND ITS CORRELATION TO PEDAGOGICAL CONTENT KNOWLEDGE

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Abstract: Although the construct of professional knowledge has been gained in center stage of educational research, content knowledge as one of the main aspects is only marginally handled. While in many studies teachers' content knowledge and its relation to other teacher characteristics are not based on a direct measurement, a large-scale test instrument for quantifying chemistry teachers' content knowledge has been developed. The development of test items in a multiple choice single select format was based on a theoretical model which considers different types of knowledge, different topics, and curricular classifications. Besides evaluation of content knowledge, a scale for describing teachers' pedagogical content knowledge was used and background information was collected. This study's sample includes 166 teachers of different school types (basic general education, extensive general education, intensified general education, and comprehensive school) which show significant differences both in content knowledge and in pedagogical content knowledge. This procedure allows for revealing aspects influencing teachers' content knowledge and information about the correlation between content knowledge and pedagogical content knowledge. Furthermore presented results serve as a basis for discussion on teacher's content knowledge needed in school, which is one main topic of the overarching symposium.

Keywords: content knowledge, large-scale test instrument, chemistry, professional knowledge, pedagogical content knowledge

BACKGROUND, FRAMEWORK, AND PURPOSE

Teachers' professional knowledge is widely believed to be one of the most important factors contributing to high quality instruction (Abell, 2007; Peterson, Carpenter, & Fennema, 1989). Recent literature conceptualizes professional knowledge in three dimensions, mainly based on Shulman's ideas for teacher education (Baumert et al., 2010; Shulman, 1987; Shulman, 1986): Pedagogical knowledge (PK), content knowledge (CK), and pedagogical content knowledge (PCK). These are seen as common facets that should be taken into account when considering competencies a good teacher should possess (Baumert et al., 2010; Grossman, 1990). This study focuses on subject-specific knowledge of chemistry teachers.

On a subject-related level, CK is conceptualized as knowledge of subject-specific facts and concepts (Cochran & Jones, 1998). Referring to Baumert et al. (2010), content knowledge is formed as a result of curriculum-related work; that is, the designing and structuring of subject-specific contents for teaching. It embodies much more than just factual, everyday knowledge based on academic fundamentals (Shulman, 1987). CK could be seen as one of four components of subject matter knowledge (content, substantive, syntactic knowledge, and beliefs), which includes some aspects of PCK, already (Cochran & Jones, 1998). PCK can be described as a fusion of pedagogical and content knowledge. This type of knowledge is used to transform a specific topic into teachable content (Shulman, 1987). When exploring teachers' CK, it can be useful to take aspects of PCK into account, additionally, because an explicit connection between PCK and CK in a teacher's knowledge base is assumed.

RATIONALE

The study is based on recent data gathered from mathematics teachers showing that teachers teaching 11-18 year olds hold more secure subject-specific CK and demonstrate better quality PCK than those teaching 11-16 year olds alone (Krauss et al., 2008). We were prompted to investigate if such findings hold true for chemistry teachers. In Germany, the locus for our study, a "non-intense", non-academic general education ends at 16. There are two school types, in which only this lower secondary age group is taught: basic general education (Hauptschule), and extensive general education (Realschule). In other secondary schools, a more intense, academic, general education is offered that ends at age 18 (intensified general education, Gymnasium) and at age 19 (comprehensive school, Gesamtschule) with the award of an entrance qualification for university. In general, CK can be assumed to be a precondition for PCK (Baumert et al., 2010).

Our study therefore investigates:

1. What differences in chemistry CK are observed in teachers teaching at intensified and non-intensified level?

2. To what extent does the quality of chemistry PCK correlate with teachers' chemistry CK?"

METHODS

166 chemistry teachers working at non-intensified level (basic general education, extensive general education), and intensified level (intensified general education, and comprehensive school) were asked to complete questionnaires probing their chemistry CK and PCK. Both were constructed in a paper/pencil form and required approximately 45 minutes to complete.

The questionnaires were based on content themes centered on 'structure of atoms and the periodic table', 'chemical bonding', and 'chemical reactions using acids and bases'. Because these topics are part of the curriculum of all middle schools, every chemistry teacher could reasonably be expected to hold CK and PCK about them.

The underpinning theoretical structure is provided by three axes (Tepner et al., submitted). Two, themes (listed above) and knowledge, are common to both tests. The knowledge axis comprises declarative, procedural, and conditional knowledge (Paris, Lipson, & Wixson, 1983). While declarative knowledge mainly refers to facts, procedural knowledge takes operations and processes into account. Conditional knowledge is knowledge about reasons and conditions under which some aspects are relevant for instruction. The third axis differs between the two questionnaires. In the CK questionnaire, the third axis was curricular classifications, which permitted grading of questions by level of difficulty suitable for students aged 12-15 (grades 7-9), aged 16-18 (grades 10-12) and first years of undergraduate study (aged 18-21). In the PCK questionnaire, the third axis was called "facets" (Park & Oliver, 2008), and comprised models, experiments, and students' preconceptions, all of which are assumed to be relevant for effective instruction (van Driel, Verloop, & de Vos, 1998).

Both questionnaires were developed in cooperation with teachers working in school for several years and lecturers in chemistry education at university. The CK questionnaire comprises 25 multiple choice/single select items (four answer alternatives per item), and the

PCK questionnaire includes 19 items. The reliability of both tests is good (CK: $\alpha = .83$, PCK: $\alpha = .83$).

RESULTS

The first research question deals with differences between teachers of intensified education and teachers of non-intensified education regarding their chemistry content knowledge. Revealed CK differences are significant ($t(164) = -10.79$; $p < .001$; $d = 2.02$ [Figure 1]).

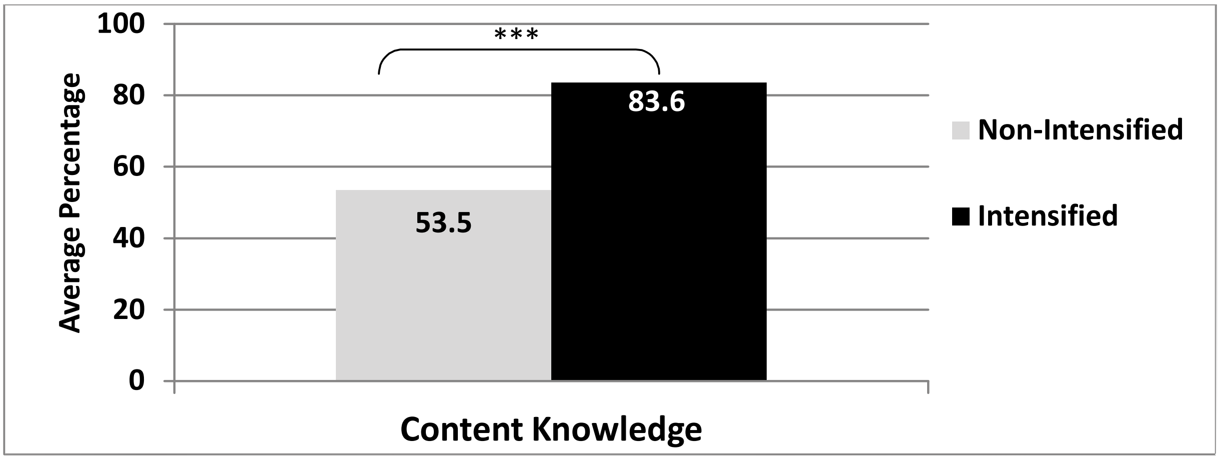

Figure 1. Differences between teachers of different school levels regarding their CK

Furthermore, CK has a substantial influence on developing PCK. While differences between teachers of intensified education and non-intensified education in terms of PCK are significant ($t(32.94) = -3.68$; $p = .001$; $d = 1.01$ [Figure 2]), PCK differences decrease when CK is incorporated as a covariate.

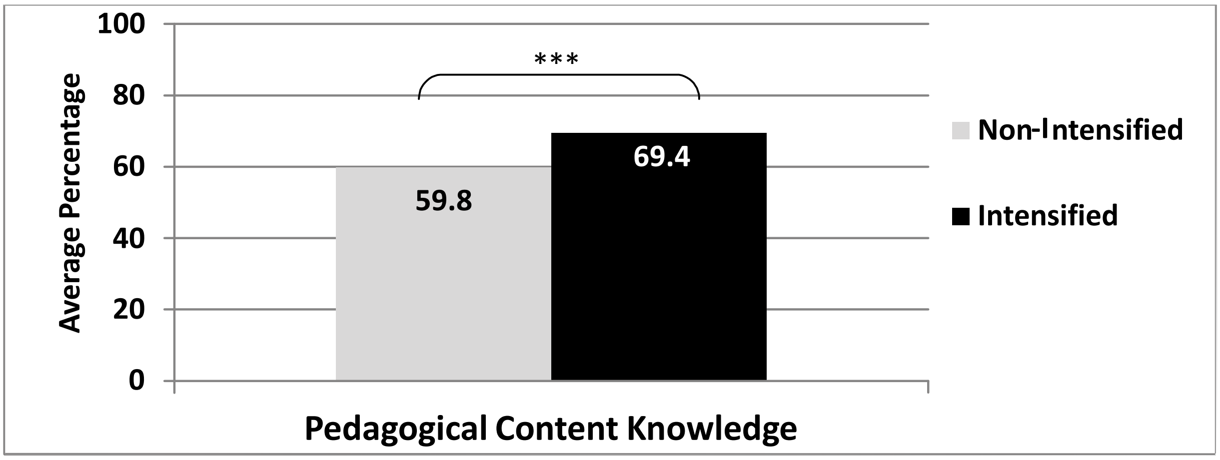

Figure 2. Differences between teachers of different school levels regarding their PCK

If CK is taken into account the ANOVA reveals a non-significant difference between intensified and non-intensified teachers' PCK ($F(1,163) = 1.413$; $p = .236$ [Figure 3].

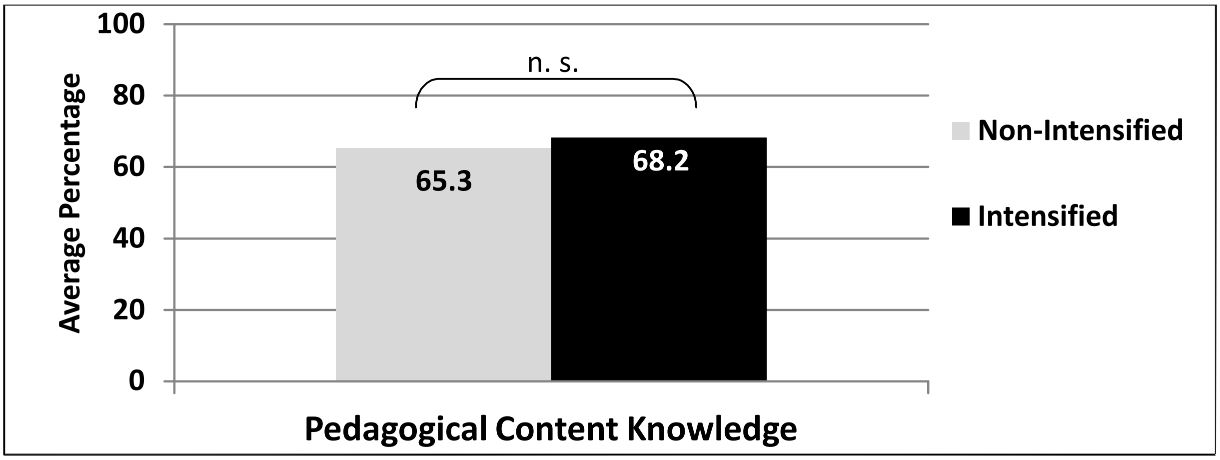

Figure 3. Differences between teachers of different school levels regarding their PCK (Covariate: CK)

The second research question analyses correlations between CK and PCK. Analysing the sample, a significant correlation of $r = .36$ ($p < .001$) between CK and PCK questionnaire can be found [Figure 4]: for example, teachers scoring highly on the CK questionnaire regarding a specific topic know much more about students' misconceptions in the same topic than those with poor quality CK, who scored badly in this aspect of the questionnaire. Nevertheless, the intensified education teachers' correlation between CK and PCK ($r = .17$; $p = .047$) is weaker than that of the non-intensified teachers ($r = .44$; $p = .018$).

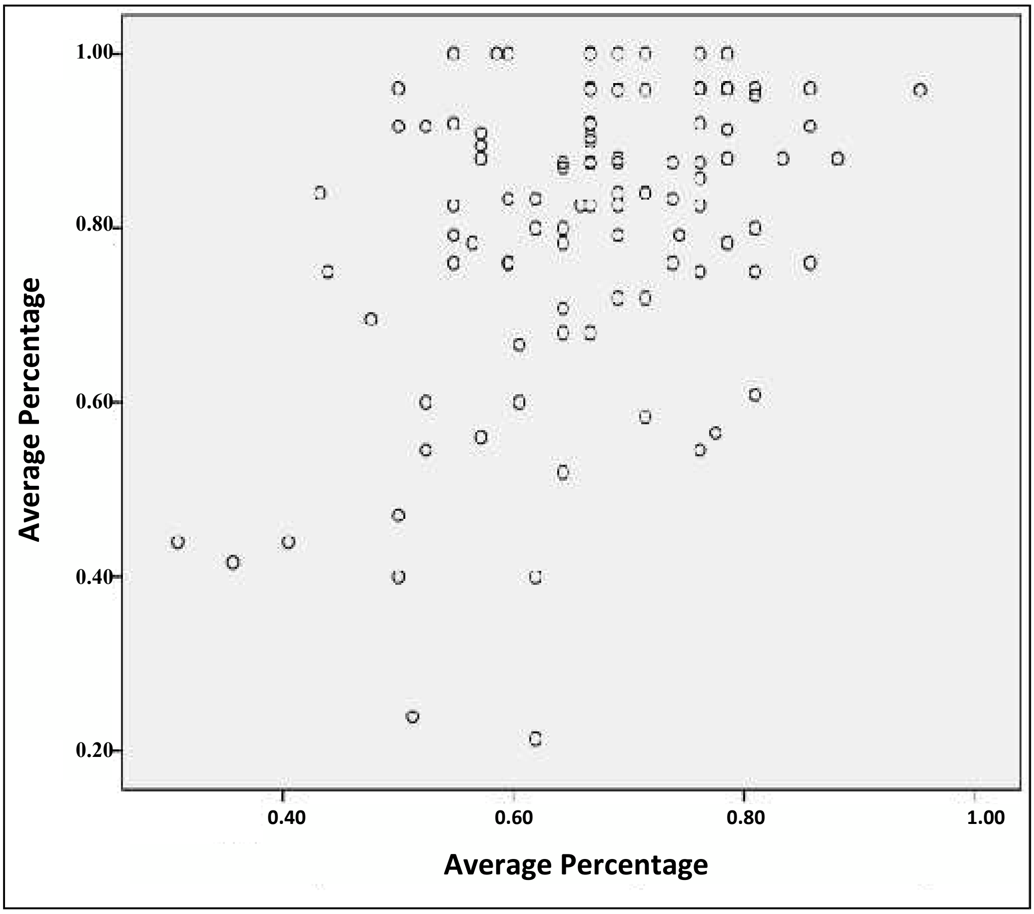

Figure 4. Correlation between CK and PCK

CONCLUSIONS AND IMPLICATIONS

Our evidence suggests that teachers' chemistry content knowledge varies according to the type of school in which they work. Teachers not using all tested levels of CK in school everyday show limited chemistry CK. The development of CK is more related to school type than development of PCK. This might be a matter of learning opportunities in studies, and a matter of requirements in daily work.

Correlation between CK and PCK is sufficiently high to be interpreted as substantial, but low enough to see CK and PCK as different dimensions (Baumert et al., 2010). The moderate but significant correlation corroborates the increasingly accepted belief that possession of good CK is a pre-condition for developing high quality PCK. Higher correlation between CK and PCK at non-intensified level might give a hint that a basic level of CK is a prerequisite for developing PCK, while a high CK does not affect a high PCK to the same extent. So CK might be a necessary but no sufficient condition for developing PCK. Additionally, intensified education teachers seem to be specialists either in PCK or in CK.

As a consequence, focusing on school type specific knowledge aspects should be reconsidered and CK immediately interlinked with PCK as it is needed in school. Discussion about this topic will contribute to recent international debate about the relative effectiveness of school- and university-based teacher education programs (Dreyer, Lesser, & Scheder, 2011; Ohle, 2010).

From a methodological point of view, this study reveals that developing and effectively using a large-scale test instrument for measuring chemistry teachers' CK and PCK is possible. The assessment tool could be used for further research on chemistry teachers' knowledge and serve as an adequate feedback tool for teachers.

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PRE-SERVICE TEACHER TRAINING: BRIDGING THE GAP BETWEEN SCIENCE AND TECHNOLOGY

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Abstract: The paper presents results of an intervention and pre-post-study with pre-service physics teacher students. As science and technology are crucial for the wellbeing of industrial countries a lot of programmes have been started by governments to improve science and technology education. Governments intend to increase the number of students and former academic workers. In the German educational system there is a clear distinction between science and technology education. While science is established at schools technology is not. There is a strong need for reintegrating technology education into the curricula of schools. We understand our work as a bottom-up-initiative to integrate technological education into school science practice. Our starting point is a pre-service teacher course: "Technology and Science Education for Physics Lessons". Students are taught important differences between science and technology. Subsequently they have to create teaching sequences of practical activities including both perspectives. Thus they are given the chance to understand the importance of technology and how to integrate it adequately into science. We study the change of students' concepts of the differences between science and technology using mind mapping, written statements and questionnaires. Results show a change of students' perspective from naïve views of technology as applied science to a more process orientated understanding of technology.

Keywords: technology education; pre-service; science education; nature of technology

THEORETICAL BACKGROUND

In Europe science and technology are important for the wellbeing of the society. While the influence of technology on our daily life is strong there is a lack of interest to study subjects of this field. Programmes in the EU[1] and USA[2] are set up to increase the interest in science and technology education (Bybee, 2000; ITEA, 2000). Governments intend to increase the number of students and former academic workers. In Germany special MINT-Initiatives[3] are supported by the government. The aim is to raise the interest in these fields and thereby the number of students in these subjects. In the German educational system we have a counterproductive structural problem: While science is well established in schools technology is not. Technology is viewed as inferior to science.

Germany has a strong tradition in preparing workers in a dual system (working in a company and attending a vocational school). As many universities refused to set up engineering courses special universities for applied sciences (‘Fachhochschule’) were founded. There is no chance to gain general technology education at the Gymnasium (upper secondary school). Initiatives to establish technology as a general school subject failed in the 1970ies. Since then a lot of out-of-school learning environments were set up by companies and engineering associations, such as student labs, science museums and technology competitions. However, our starting-point is the regular school curriculum because we believe that technology cannot only be taught in out-of-school environments. We are aiming at a more systematic technology education and intend to develop pre-service physics teachers’ understanding for the necessity of technology education.

A pre-service teacher course: Science and Technology Education in Physics Lessons

Students in science education have no systematic technology education and tend to have naïve views about the nature of technology (Constantinou, Hadjilouca, & Papdouris, 2010). Students see technology as applied science and some even do not think that it is an academic discipline. Thus a pre-service teacher course is set up aiming at the change of concepts of the nature of technology. The idea is to explain the different perspectives and processes of technology and science (Eisenkraft, 2003; Wonacott, 2001; Euler, 2008.). Students have to plan a school project to use the new ideas in a specific situation. Possible topics are energy supply, production and automation, innovative engines, optimization of wings and Leonardo da Vinci’s machines. Students analyze curricula and have to make their own decisions about methods. They have to integrate learning aims and perspectives from both sides: science and technology. Consequently they have to rethink their attitudes and values referring to science and technology (Bell & Lederman, 2003).

RESEARCH QUESTIONS

What concepts do students hold about the differences and links between science and technology?

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[1] http://ec.europa.eu/education/lifelong-learning-policy/doc1120_en.htm
[2] http://www.iteaconnect.org/TAA/Publications/TAA_Publications.html
[3] MINT: Mathematics, Information technology, science, technology; http://www.mintzukunftschaffen.de/

To which degree can students' concepts of technology be developed by special teacher training courses? To which degree can students' conceptual awareness of the differences and links between science and technology be developed?

DESIGN AND METHODS

We use a pre-post-test design to investigate the development of students' attitudes towards technology education and their understanding of the differences and links between science and technology (fig. 1). Students are asked to do a two-step-brainstorming: First they draw a mind map starting with 'science' and 'technology' already written on the sheet and are asked to complete the map using terms and links. Then they write a statement of about one page commenting the mind map. Finally they fill in a questionnaire about their former education in technology, a semantic differential about science and technology and their attitudes towards technology in school.

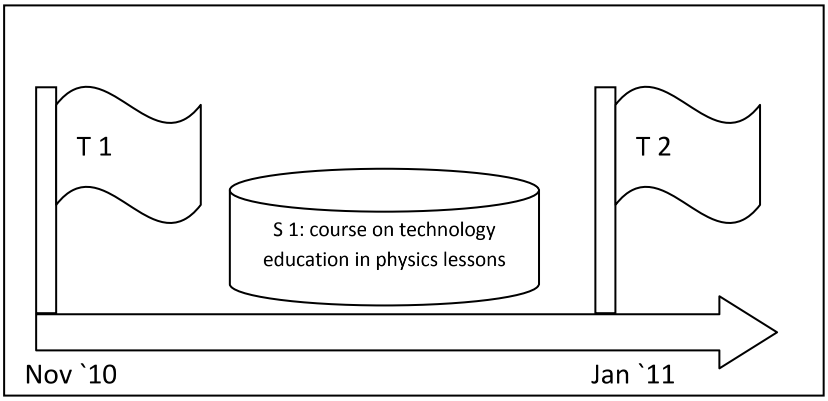


Fig 1: design of the study; intervention with pre/post-test

T1: mind map, statement, questionnaire
S 1: pre-service course for physics teacher students (theoretical input, comparative analysis of science and technology curricula, planning of a school project, presentation and discussion)
T 2: mind map, statement, questionnaire
49 persons filled in the questionnaire at T1 and 15 attendees of the seminar participated in the whole study T 1 – S 1 – T 2.

Due to the low number of students in the course statistical methods can rarely be used. To get more general information about former technology education and general attitudes we raised the number of students who filled in the questionnaire up to 50. The study will be continued with following courses in winter 2011/2012. We are now developing the questionnaire and planning to raise the number of participants (pupils, students, in-service teachers).

RESULTS

Questionnaire

The questionnaire was completed by 49 participants (physics teacher students, 60 % male). The attendees of the seminar also were physics teacher students who are in the master level (60 % male). Every participant had physics lessons at school (tab. 1). No attendee had technology lessons. Only one participant reported to has had technology lessons at school.

31 % of the schools had optional study groups for technology, 51 % a project group on stage equipment and event technology (tab 1). 22 % of the schools attended in technology competitions, 16 % offered other courses related to technology.

Tab 1: Optional technology courses at schools

	Optional study group technology	Project group on stage equipment and event technology	Participation in competitions	Other
Participants study	11 (32 %)	16 (47 %)	10 (29 %)	3 (9 %)
Attendees of the course	4 (26 %)	9 (60 %)	1 (7 %)	5 (33 %)
all	15 (31 %)	25 (51 %)	11 (22 %)	8 (16 %)

Students mainly perceive technology as applied science (fig. 2). In this aspect there are no differences between attendees and other students. Even the post test results show that this is a strong concept. This concepts is appropriate as one aspect of a sophisticated view of technology. But the analysis of the mind maps (chapter below) shows that the over emphasis on this singular aspect can be seen as a rather naïve view on technology.

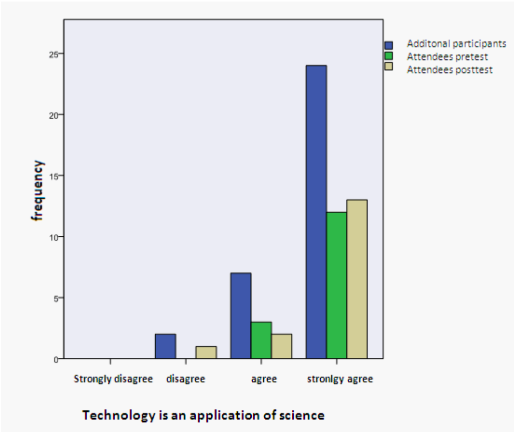


Fig 2: technology as an application of science

In the pre test students do not agree that technology is an independent academic discipline (fig. 3). Only in the post test students tend to agree that technology is an academic discipline even though their university has a strong emphasis on mechanical and electrical engineering. With larger test samples we expect to find significant differences. We interpret this as a learning outcome of the course where we focus on the processes of technology. Students get insights into the rich and valuable tools and procedures of academic technology. Through the seminar some of the students expressed their changing views of these aspects. Some even reported that they went through a conceptual change of their views of technology.

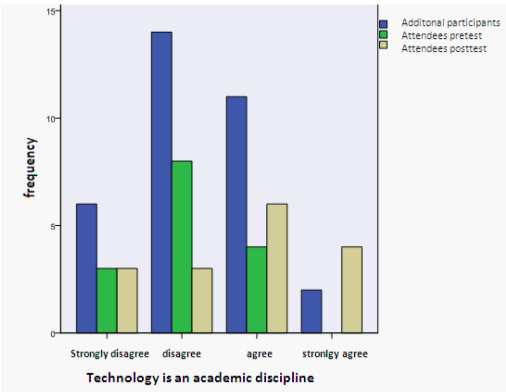


Fig 3: technology as an academic discipline

Mind Maps

Students link 54 % of all used terms to ‘technology’ in the pre-test. In the post-test 63 % of the terms are linked to technology (fig. 4). The terms linked to ‘science ‘slightly decline from 55 % to 52 % (pre to post test). From pre to post test the percentage of terms placed in the middle of ‘technology’ and ‘science’ raises from 12 % to 20 %.

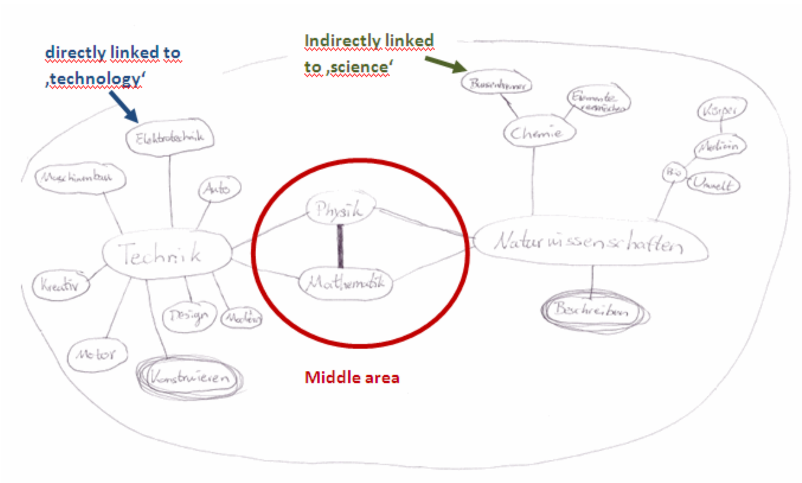
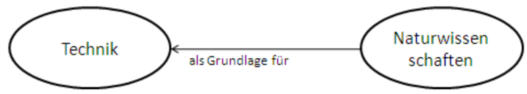
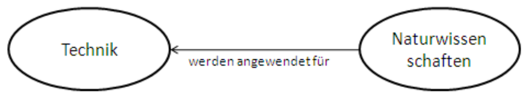
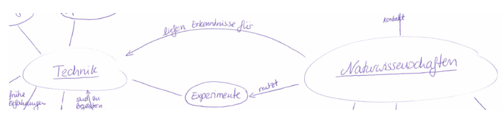
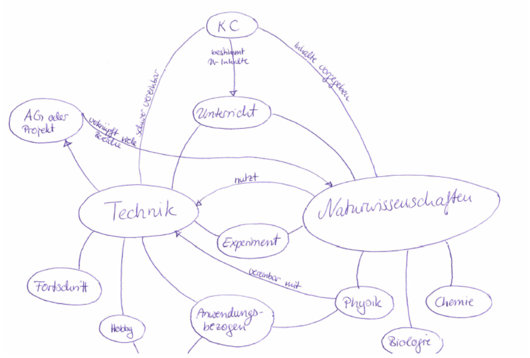


Fig 4: example map with comments

To indicate the interconnectedness of 'technology' and 'science' we counted the direct and indirect bridges from one to the other. Then we calculated the ratio of this number to the total amount of terms in each map. On average we find an increase of this indicator from 0,14 to 0,18. Due to the small number of cases we cannot rely on the result. Further studies with larger samples will show if the hypotheses driven from this study can be verified. In depth analyses of the bridging between 'technology' and 'science' have shown that there might be two classes of development from pre to post test. The indicator might not be appropriate to describe a general behavior. We find a group of students (I) who do rarely change their concepts and views of technology and science (tab. 2). On average they have the same or even a lower amount of links in their maps. Another group (II) of students shows a significant change of concepts and views. Interestingly the mind maps of those attendees show an increase of interconnectedness. We find 8 students in group I and 7 students in group II.

Tabelle 2: examples for the connection of technology and science

	pretest	posttest
I		
II		

The attendees however developed on average a more appropriate understanding of technology. Additionally to the view of technology as an applied science one finds as well more developed opinions about technology as an independent academic discipline. Aspects like the final perspective, processes as optimization and design form their understanding of technology. Thus they consider technology more relevant for school education.

Interestingly some students use terms like fantasy, curiosity, and convenience to distinguish between science and technology. They contribute to a deeper understanding of scientific and technological processes which is often missing in teacher education and school science classes. In one map (5) we find terms like ‘progress’, ‘curiosity’, and ‘fantasy’. In another map (13) we find ‘danger‘, ‘responsibility‘, and ‘coincidence’. Further in depth analysis of cases will give an insight into the evoked associations. These examples demonstrate that the terms ‘technology’ and ‘science’ can be understood in many different contexts, e.g. education, society, ethics, academic system.

RESUMÉ

Findings approve that technology is mainly perceived as an application of science. The attendees of the seminar however develop a more differentiated perspective of technology and science. Especially they have deeper insights into interrelations between science and technology and the resulting effects on society. We are planning to conduct the course again, also for in-service teacher education. We assume that the understanding of the interrelations between science and technology is crucial for the development of technology education in schools. Results presented in this paper give reasonable prospect that a conceptual change in the views of technology and science can be triggered trough such a course. Thus we find it fruitful to develop different modules for in-service teacher training and to evaluate the impact of such an intervention.

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HOW SCIENCE WORKS: A LONGITUDINAL STUDY OF PRE-SERVICE TEACHERS' FIELD EXPERIENCES OF SCIENCE CURRICULUM CHANGE IN ENGLAND

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Abstract: This paper reports work by University providers with pre-service teachers into how a major revision of the curriculum in England, *How Science Works*, has been translated into practice in their schools. Data were collected by pre-service teachers over three years about their understanding, experiences, perceived challenges and resourcing of *How Science Works*. The results indicate that implementation of *How Science Works* continues to lie on a spectrum between two extremes referred to as creative implementation and restricted implementation; that pre-service teachers' have improved their understanding of the processes of science and how these relate to higher order thinking skills; that reliance on published resources remains high; that there is an increase in student-centred approaches and some shift from content towards process but that the dominance of assessment remains. Students' engagement with the new curriculum is variable, being most successful when teaching is appropriate to ability, actively involves students and is sufficiently challenging; engagement is negative where a content laden curriculum remains. The paper concludes that the key areas for change are higher order thinking skills, appropriate differentiation and a transition from teaching facts to developing concepts, with pre-service teachers being paramount as agents for change.

INTRODUCTION

This paper reports how a major change in the science curriculum, the inclusion of *How Science Works* in the National Curriculum for England, has been implemented in schools over a three-year period, as experienced by pre-service science teachers' reports. In doing so it seeks to add to knowledge about science curriculum change by providing insights into how a new curriculum initiative has been introduced in a range of secondary schools (ages 11 to 16 or 11 to 18 years) and identifies trends over the three-year period. This work can inform international science education researchers and curriculum developers about a model of curriculum change at a time when a number of countries are experiencing changes that reflect students' views about science, the relevance of science to their lives and their views about the advanced study of science (e.g. Jenkins and Nelson, 2005; Sjøberg and Schreiner, 2005). In doing so, this work will inform those involved with science teacher education at both initial (pre-service) and experienced (continuing professional development) levels to ensure that they are confident about the philosophy and practices for effective integration of change, in this case that of *How Science Works*, in science classrooms. In this paper we analyse both the variety of approaches to implementation and the trends over the three years of the project

BACKGROUND

In common with a number of countries worldwide (INCA, 2008), school students in England follow a statutory national curriculum for science that sets out programmes of study and level descriptions for the assessment of all 5 to 16 year olds (QCDA, 2007). Various revisions between 1989 and 2004 led to four main attainment targets that were essentially concerned with scientific enquiry (inquiry), biological, chemical, and physical processes. In 2004, a major change occurred that saw the inclusion of *How Science Works* where, at Key Stage 4 (14-16 years), teachers should ensure that the knowledge, skills and understanding of how science works are integrated into the teaching of science content (QCDA, 2007). Within the *How Science Works* programme of study are four main subsections: data, evidence, theories and explanations; practical and enquiry skills; communication skills; and applications and implications of science. These changes commenced in schools with Key Stage 4 in September 2006 and with Key Stage 3 (ages 11-14 years) in September 2008.

Changes to the 2004 curriculum originated at the instigation of prominent science educators that culminated in the document *Beyond 2000* (Millar and Osborne, 1998). This seminal document was the product of a desire to provide a vision of science education that addressed the needs and interests of young people as future citizens at the end of the 20th century. One important outcome from *Beyond 2000* was the inception of the Twenty-First Century Science project that was the first attempt to develop and pilot a major curriculum initiative and to use evaluations of the pilot to inform further development (Burden *et al*., 2007).

Whereas our previous ESERA paper (Golabek *et al*., 2010) reported how the new curriculum has been implemented, this paper reports the trends of these implementations over a three year period and takes into account the extension of the *How Science Works* strand into Key Stage 3.

Importantly, our interest as both researchers and teacher educators – and one related to *who* implements new approaches to teaching and learning – concerns the role of pre-service teachers (referred to as 'trainees') in implementing curriculum change. Taber *et al.* (2006, 64), in providing a rationale for including a project on ideas and evidence (part of the How Science Works strand) in the pre-service training year, highlights the concern that 'there may be limited good practice in many schools' and that pre-service teachers can become models of good practice. They are therefore more likely to be in the vanguard of change as change agents when they enter the teaching profession (Braund and Campbell, 2010). Trainees' developing awareness of curriculum change and schools' approaches to it have been raised in that they have had the opportunity to share these experiences with their peers, encouraging them to see this an important area in their future work.

RESEARCH QUESTIONS

In order to find out *How Science Works* for trainee teachers, we posed two research questions:

1. Is there a paradigm shift in terms of a change in the pattern of science education with a move from teaching facts to understanding concepts? This would represent a change in thinking, or *Mind set*.
2. Is there an associated change in pedagogy in terms of (i) *Mind set* (ii) *Methods* and (iii) *Materials*?

With trainees from a variety of science backgrounds, whether it be subject discipline, research, business or even their own experiences of school science, our first research question is important in order to gather data on their own understanding of *How Science Works* and their underpinning views about the way that science is taught. Our second question is rather more pragmatic in gathering data about how *How Science Works* is seen in practice. We want to know what changes have occurred in science classrooms in terms of the pedagogy involved and how this is supported. In particular we want to explore the changes in thinking about how science is taught and the effects of this on both teachers and students

METHODS

Three university providers of pre-service teacher education in and around the London region participated in this study with a cohort of 70 trainees during 2008 and 50 in 2009. The final year of the study, 2010, saw the participation of two University providers and a total of 44 trainees. Trainees study a one year course that includes University taught elements and two blocks of observation and teaching experience in schools. The study was carried out in two-stages. Stage 1 involved five questions that were emailed to trainees during their final period of school experience, to direct their focus on *How Science Works*. The questions were related to the three aspects of pedagogy in the research questions and provided a stimulus for trainees' thinking about *How Science Works*.

Q1: What do you understand by *How Science Works*? [Mind Set]
Q2: Describe the resources that are being used in your present practice school [Materials]
Q3: What are your experiences of teaching approaches to *How Science Works* at KS4? [Methods]
Q4: What challenges have you experienced with teaching *How Science Works*? [Methods]
Q5: How do you see that students receive *How Science Works*? [Mind Set]

Stage 2 involved small discussion groups in the final weeks of the University course. Trainees were then asked to summarise their discussions on a poster. They then went to the next questions and repeated the process adding to the responses recorded by the previous group. The data from the trainee groups of the providers were analysed collaboratively to categorise emergent themes.

A qualitative approach was adopted in order to provide open-ended responses that allow trainees to report both their understanding and observations for each question and in detail. Quantitative approaches using Likert-type responses would have provided us with data about what changes were experienced in schools, in response to closed questions, but would have been limited in the level of detail which was possible with the qualitative approach used. The use of emailed questions instead of interviews were used as a more efficient approach to surveying larger numbers of trainees over the limited time 'window' available and for providing a more convenient approach for data analysis. Furthermore, the use of agreed emailed questions between University providers was able to increase the level of reliability with the same questions asked to all participants

RESULTS AND DISCUSSION

Trainees' understanding of How Science Works

Trainees' own understandings appear to operate at two levels. At one level, that of their understanding content of the new curriculum, the relevance of science and its applications to real life, their perceptions remains similar over the three years of the study. At another level, there is an emerging trend with their increasing views about transferable, cross-curricular skills that related to higher order thinking skills (such as the nature of data and evidence, analysis and explanations) and an increased understanding of the processes of science and a better understanding of how scientists work. This is shown in this example:

> *It also makes them think about the concept of evidence and how science works in the way that theories only come about by evidence, and if something is contrary to it, then a new hypothesis must be made and tested.*

Despite comments of this nature, there remained a noticeable lack of any mention of history of science or scientists and the link to communication skills remained minimal.

In the mid 1950s, Bloom (1956) formalised the idea that different types of learning might require different levels of cognitive processing. He identified six levels: remembering facts, understanding their relevance and being able to apply this knowledge and understanding were classed as lower order thinking skills (LOTS). Important in their own right, but forming the base of a pyramid from which other higher skills are able to develop. The ability to analyse, evaluate and synthesise, and the ability to create new knowledge, are classed as higher order thinking skills (HOTS). These require a higher level of reasoning and intellectual processing such as critical thinking and problem solving and thus require a different approach to teaching and learning. These higher order skills are more difficult to master, but are considered more valuable as transferable skills particularly in application to new situations. It is the trend towards these higher order thinking skills that is more evident in the data over the three-year period of this study.

Resources used in practice schools

A heavy reliance continues over the period with the use of published resources, both text and ICT resources. Furthermore, there is an increased dependence on resources directly linked (and often published for) specific examination specifications. This further confirms the dominance of assessment, a 'teaching to the test' approach to science, particularly so at KS4. There are strong indications that teachers are pressed to complete the specified work within the set timescales. Practical work and developing manual skills, experimentation, data gathering and more open ended work, compared to previously prescribed practicals, takes longer to prepare and carry through a sequence of lessons. Preparing a class for discussion with time for research, planning, preparing presentations, all takes time. And yet at the end f it all there are still exams to pass! It is therefore hardly surprising that teachers in schools fall back on published and on-line resources.

Teaching approaches to How Science Works

We have noted a number of trends over the here years of the study. Debates and discussions remain an ongoing part of *How Science Works*. There is an increased use of short video clips and internet resources; increased adoption of student-centred approaches such as independent research and writing; a shift away from content towards process and with it a shift from the teacher as transmitter of content to facilitator, and the student as passive to active learner; a greater emphasis on investigative work. However, but there remain problems for the lower ability students (see below on challenges); there remains no change in teaching to the test with assessment taking a dominant position within science departments in schools. There are ongoing reports of a lack of time, resources, funding and teachers' understanding of *How Science Works* in the curriculum, including a lack of training with the new approaches and reports of a lack of departmental support.

On the positive side, enthusiasm and creativity in relation to *How Science Works* was depicted in the trainee responses that included broadening students' perspectives by a focus on the 'real life' of current affairs, contemporary and ethical issues, and giving students more responsibility by putting them in charge of their own decisions and judgements. Scientific ideas were reinforced by their applications. Teachers with a more positive mind set integrated *How Science Works* into their schemes of work, which led to teaching methods linked to the world around them, engagement with current affairs through newspapers and the Internet and adaptation of materials to address learning styles. Teaching specific terminology was an anticipated need, and methods such as drama were used effectively. However, these positive changes over the three-year period to curriculum change tended to be in the minority.

On the more negative side, trainees detected that some teachers were still stuck within a content laden curriculum mindset, not having yet prepared for the needs of students and anxious about workload issues to cater for the new curriculum. They had anticipated neither the difficulties that lower ability students would have in analysis and evaluation of evidence nor the National Curriculum requirement to improve communication skills. A perception that content needed to be delivered more slowly meant that a tension was evident as teachers struggled for time. Students failed to see the purpose of what they were being taught because the teaching was insufficiently related to students' interests.

Challenges with teaching How Science Works

Implementation of *How Science Works* in schools lies on a spectrum between two extremes which we refer to as *creative implementation* and *restricted implementation*. With creative implementation, trainees report that there have been some creative transformative practices to meet the aims of the recent National Curriculum. There is a trend in students being encouraged to take responsibility particularly in planning practical work and in discussions. This approach has resulted from forward planning, which has involved all staff in the adaptation of existing resources and the development of bespoke materials. *How Science Works* was fully integrated into the core of schemes of work together with appropriate training for both teachers and technicians.

With restricted implementation, teachers seem unsure of the new curriculum and what *How Science Works* is about. Trainees seem to be picking up negative signals from some schools that *How Science Works* is not being integrated into schemes of work. However, commercially produced schemes of work and CDs are adopted. Some teachers have difficulty in making the transition from teaching facts to developing concepts so that the broader aspects of *How Science Works* are bolted on to the existing curriculum. There seems to have been a lack of forward planning and teaching is centred on assessment with tasks and examination questions being used from the end of Key Stage 3.

How students receive How Science Works
On the positive side, the trainees report that students enjoy *How Science Works*. They are keen and interested, particularly so where the subject matter is relevant to their experience and with engaging practical work. Lessons are more enjoyable and productive as relating things to everyday life makes science fun. *How Science Works* activities are useful and achievable, with the majority of trainees believing that hands-on practicals to be the most enjoyable. For low achievers, less theory with more examples and activities appears to be the way to keep students engaged. The more able students respond well to investigative skills development like evidence based thinking, data collection, the scientific method and critical analysis. *How Science Works* has to be specifically tailored to meet the needs and differing ability students. On the negative side, there is continuing difficulty with the need to engage students at different levels; where appropriately challenging work for the more able produces problems such as disengagement and difficulty for the less able. Conversely, work that is designed to engage the less able can lead to boredom and disengagement with the more able. Students continue to have difficulties with vocabulary, definitions, understanding key concepts, such as variables, validity and reliability. There is some evidence that Key Stage 4 students lose interest in *How Science Works* because of the overarching pressure of external examinations. Students are not really aware that *How Science Works* now forms the core of science learning and instinctively look to be taught in a more traditional manner. This is not helped by some of the more restrictive departments where there appears to be difficulty with understanding the concept and integration of *How Science Works* and with implementing it, including little deviation from a previous teaching style, which may be a response to the legacy of past curriculum over-prescription.

Over the three-year period of the study we have observed an increased awareness of the need for differentiation. There are indications that both low and high ability students can engage in and enjoy this new approach but at differing points on the teaching and learning spectrum. For lower ability students, the materials, level of engagement, pace of lessons must be tailored to their needs. In this environment the more able quickly become bored and disengaged. For the higher ability students, operating at the analysis-evaluation and even creative levels is a stimulating challenge to which many respond with enthusiasm. For the less able, this is beyond their immediate capabilities and results in confusion, frustration and very quick disillusion with learning, which then often leads to behavioural and classroom management issues.

CONCLUSIONS AND IMPLICATIONS

The findings of this longitudinal study indicate a shift in adoption of new pedagogies and approaches associated with curriculum change, that of *How Science Works*, in science classrooms. This shift is demonstrated with a move from a restrictive to a more creative implementation of *How Science Works* over the three-year study, to a realisation by trainees of the importance of differentiation to provide challenge and engagement for all students, and to the increasing importance of higher order thinking skills and their transferability. Trainees' own understanding of How Science Works has improved in terms of the nature of transferable, cross-curricular and higher order thinking skills, and an increased understanding of the processes of science with a better understanding of how scientists work. However, trainees report that assessment still remains a dominant feature in many schools, as does an increasing reliance on published resources.

Trainees' time spent in schools, time that takes up two thirds of the one year pre-service teacher education course, is an important part of their education programme as they develop as beginning teachers. This is especially important at a time of dramatic curriculum change in schools that goes beyond trainees seeing classrooms in terms of personal theories, generalisations about students or ways of representing subject knowledge (Furlong and Maynard, 1995), but with an enhanced awareness of the pedagogies of science education and the changes that affect teachers' work. The timing of eliciting trainees' responses were intentionally directed towards the end of the one-year teacher education course as being a time when they would be expected to have moved beyond the earlier stages of idealism, personal survival and dealing with the difficulties associated with this, to reaching a plateau (Furlong and Maynard, 1995) and being at the final stages of moving on to understanding the constraints involved with teaching and learning, beyond the 'good ideas' for teaching science and into the growth of professional knowledge. We are therefore starting to deal with trainees at the autonomous stage of their teacher education journey, a stage exemplified as a broadening of their repertoire of strategies, a deeper understanding of the complexities of teaching and learning and a consideration of the social and moral dimensions of their work.

Curriculum change and resulting pedagogies are important aspects of a beginning teacher's continuing development as responsive, thoughtful and skilled practitioners. The trainees' reports of practice in this study have allowed their awareness of curriculum change and schools' approaches to it has been raised, and they have had the opportunity to share these experiences with their peers, encouraging them to see this as an important area in their future practice. It is through these reported experiences that beginning teachers can become vanguards for exemplary practice that involves them as agents for change when they enter the teaching profession (Braund and Campbell, 2010).

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PRACTICAL STUDY ON ARGUMENT SKILL IMPROVEMENT IN PRE-SERVICE TEACHERS

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Abstract: Recently science education has focused on the development of learners' argument skills. Argument skills are believed to be an important quality not only in learners but also in teachers. Yet it is pointed out that teachers' argument skills are limited (Zohar, 2008). In this study, we implemented a curriculum aimed at improving pre-service teachers' argument skills and effectiveness.

Developed by Seethaler & Linn (2004), the curriculum addresses genetically modified foods as a socio-scientific issue. Our target group comprised 43 Japanese pre-service teachers. Before and after implementation of the curriculum, surveys were conducted concerning the issue of "nuclear power generation," a topic different from what our pre-service teachers had learned through the curriculum. Based on the Knowledge Integration scoring scheme developed by Seethaler & Linn (2004), of the elements studied, "evidence against chosen position" and "conclusion to overall argument" showed a particularly significant improvement in scores from before to after curriculum implementation. Significant correlations between these two elements after curriculum learning were also identified.

These results indicate that the curriculum is effective in argument skill improvement, not only in junior high school students, but in pre-service teachers as well. Also, it became clear that this curriculum improves 1) the skill element of using not only evidence that supports one's argument, but also evidence that contradicts one's argument and 2) the skill element of drawing weighted conclusions. It is suggested that promoting the use of evidence produced by conflicting standpoints can be a design principle for curricula aimed at improving argument skills.

Keywords: argument skill, pre-service teachers, evidence, socio-scientific issue, design principle

BACKGROUND

Argument is a series of verbal forms intended to establish a certain claim through, for instance, backing and rebuttal, or a series of verbal exchanges that contain such elements (Toulmin, 1958). In recent years, science education places importance upon and pays attention to the improvement of argument skills in learners (Erduran & Jiménez-Aleixandre, 2008). PISA's interpretation of scientific literacy includes the capacity to draw evidence-based conclusions with respect to scientific questions (OECD, 2007). Argument skills constitute an important quality not only for learners, but also for teachers engaged in giving lessons to learners.

THEORETICAL FRAMEWORK

In today's society, where issues concerning science, technology and the environment abound, learners are required to have argument skills to establish evidence-based claims, considering conflicting standpoints (Duschl & Osborne, 2002). Against this background, present-day teachers must have not only content knowledge or pedagogical content knowledge, but also high-order thinking skills, such as argument skills (Zohar, 2008).

In reality, however, it is noted that teachers' argument skills are limited. For example, on the basis of her studies targeted at pre-service teachers, Zohar (2008) points out pre-service teachers' inability to connect evidence to claims, and their propensity toward hasty conclusion and generalization.

Unless teachers have high argument skills, it is extremely difficult to improve argument skills in learners. For this reason, we thought it an urgent task to obtain knowledge concerning the improvement of teachers' argument skills, if we wish to improve said skills in learners.

PURPOSE OF THE STUDY

Targeted at pre-service teachers, this study implemented a curriculum designed to improve argument skills, and evaluated its effectiveness. The curriculum, which addresses genetically modified foods as a socio-scientific issue, was put together by Seethaler & Linn (2004). While the Seethaler & Linn curriculum (2004) is geared to junior high school students, it is also predicted to be effective for pre-service teachers not particularly trained in argument concerning socio-scientific issues.

In this study, we asked the following two research questions:

a) Does the curriculum of Seethaler & Linn (2004) improve pre-service teachers' argument skills?

b) If the answer to (a) is positive, which elements of the argument skills does the curriculum improve?

RESERCH DESIGN AND METHODOLOGY

Subjects

Subjects of this study comprised 43 third-year students at the education departments of Japanese national universities who were seeking teacher's qualification. None had experienced learning about argument concerning socio-scientific issues.

Duration of study

A total of 6 class hours (90 minutes ! 6 times) in October-November 2010

Curriculum outline

This study used a curriculum developed by Seethaler & Linn (2004). Table1 shows the process of our curriculum. At the outset, we raised the issue of genetically modified food development and had the students read materials to obtain basic knowledge of gene recombination technology and its differences from natural crossbreeding. We then presented materials, each either for or against this issue, and conducted an activity involving argumentative discourse using those data (Figure1). At the end of the curriculum, students were required to write a position paper expressing their respective standpoint .

Table1. The process of our curriculum

process	class hour	activity
1	1	Discuss about the issue of genetically modified food development.
	2	Read materials to obtain basic knowledge of gene recombination technology and its differences from natural crossbreeding.
2	3-4	Read materials each either for or against this issue as evidences.
3	5	Callenge an activity involving argumentative discourse using evidences.
4	6	Write a position paper expressing their respective standpoint.

Figure1. An activity involving argumentative discourse using data (process3)

Test and survey

To assess pre-service teachers' argument skills, tests were conducted before and after curriculum implementation regarding to the issue of "nuclear power generation," different from the issue learned through the curriculum. In these tests, each student was required to read materials expressing opinions both for and against nuclear power generation (Table2), and to write a position paper (one A4 page) supporting his or her position concerning this specific issue. In other words, argument used for the tests were identical in structure to those concerning the genetically modified foods issue addressed in the curriculum, but differed in terms of content of argument. Using the questionnaire method, the time spent on each survey was 20 minutes.

Table2. Opinions both for and against nuclear power generation

For nuclear power generation	Against nuclear power generation
Nuclear power generation are safe.	Nuclear power generation are not safe.
Nuclear power generation are good for environment.	Nuclear power generation are bad for environment.
Nuclear power generation make vast electrical energy.	Nuclear power generation cost oceans of money.

Analysis

Based on the Knowledge Integration scoring scheme developed by Seethaler & Linn (2004), we scored responses concerning the survey subject. This scheme was developed in accordance with Toulmin's framework concerning the structure of argument (Toulmin, 1958). Of the five elements constituting the knowledge integration scoring scheme, for "evidence in favor of chosen position," "evidence against chosen position," and "counter-evidence to evidence against their position," a response without description was scored "0," a response with descriptions "1," and a response with ample explanation "2." For "normativity," a response that was not appropriate was scored "0" and one that was appropriate "1." For "conclusion to overall argument," a response without a conclusion was scored "0," a response containing either a pro or con conclusion "1," a response that weighs evidence from both standpoints but contains inappropriate pieces of evidence "2," and a response weighing evidence from both standpoints with all pieces of evidence contained therein appropriate "3." The highest score, therefore, is 10. Two of the authors conducted the scoring independently from each other. The concordance rate turned out to be 89.2%. Discordance was corrected through consultation.

DATA ANALYSIS AND RESEARCH FINDINGS

Table 3 shows total scores and score distribution for each element before and after the curriculum learning. As a result of Wilcoxon's signed-rank test, total scores improved significantly from before the learning to after the learning (Z=2.33, $p < .05$). Of the scores given to each element, those for "evidence against chosen position" and "conclusion to overall argument" showed a significant improvement from before the learning to after the learning (Z=1.81, $p < .10$; Z=2.32, $p < .05$). Assessment using Spearman's rank correlation coefficient revealed significant correlation between these elements after the learning ($r = .33$, $p < .05$). Meanwhile, no significant change was identified from before to after the learning with respect to "evidence in favor of chosen position," "normativity" and "counter-evidence to evidence against their position ($p > .10$).

Table3. Distribution of knowledge integration scores.

Element of argument	scores	Number of students achieving each KI score	
		pretest	posttest
Evidence in favor of chosen position	0	2	I
	1	28	32
	2	13	10
Evidence against chosen position	0	9	1
	I	30	39
	2	4	3
Normativity(presence/ absence of non-normative ideas)	0	1	3
	1	42	40
Counter-evidence to evidence against their position	0	32	27
	I	II	14
	2	0	2
Conclusions to overall argument	0	4	1
	I	35	29
	2	0	0
	3	4	13

CONCLUSIONS AND IMPLICATIONS

The above results are believed to indicate that the curriculum developed by Seethaler & Linn (2004) is effective in argument skill improvement, not only in junior high school students, but also in pre-service teachers. Furthermore, it became clear that this curriculum improves 1) the skill element of using not only evidence that supports one's argument, but also evidence that contradicts one's argument, and 2) the skill element of drawing a weighted conclusion.

Jiménez-Aleixandre, M. P. (2008) proposes, as design principles of argumentation, "choosing among two or more competing explanations or theories" and "backing their claims or choices with evidence." The curriculum developed by Seethaler & Linn (2004) is characteristic in promoting the use of evidence from conflicting standpoints. From these earlier observations and the results of this study, promoting the weighting of conclusions using evidence against one's argument can be a design principle of a curriculum that helps improve argument skills concerning socio-scientific issues, regarding which several different arguments can be made.

Meanwhile, this study indicates that students able to reach weighted conclusions after the curriculum learning represented only about 30% of the survey group. The study also revealed that no improvement was achieved for the element of rebuttal using evidence. In the years ahead, therefore, studies must be conducted with regard to learning support tools that help improve these elements.

ACKNOWLEDGEMENT

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PART 13: IN-SERVICE SCIENCE TEACHER EDUCATION

Co-editors: Jouni Viiri and Digna Couso

In-service science teacher education, teachers as lifelong learners; methods, innovation and reform in professional development; evaluation of professional development practices, reflective practice, teachers as researchers, and action research.

This part corresponds to strand 13. It contains 32 papers.

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IN-SERVICE SCIENCE TEACHER EDUCATION

NANOSCIENCE AND NANOTECHNOLOGIES EDUCATION : TEACHERS' KNOWLEDGE

Virginie Albe[1]
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Abstract: "Nano Education" is an emergent field of research, in line with research in nanosciences and nanoteachnologies. Curriculum design to integrate nano in education, from kindergarten to university is also an intense field of interests. Recent efforts have been devoted to document students understanding on nanoscale, to develop and implement innovative "nano" devices for teachning and to train science teachers on nano. Inn this paper, science teachers understanding of nano and intentions to teach nanos were investigated in the context of a summer school. Pre and post questionnaires were used. ategories were elaborated by an iterative coding process. Pre-post tests comparison of teachers' knowledge show that nanoscience and nanotechnologies mostly defined a minima by the nanoscale size in the pre-test were also apprehended with specific physical properties and applications in the post-test. Teachers tend to favor specific designed teaching activities to integrate nanoscience and nanotechnologies in class. Results also suggest an openness to curriculum activities in relation to educative aims broader than science concepts learning. Teachers intentions show extra-discipline based curriculum activities with educative aims in relation to an understanding of science in the making, argumentation, information literacy and citizenship education. This encourages to develop science education research linked to the design of teaching activities on a nano-literacy.

Keywords: Nanosciences - Nanotechnologies - Secondary education - Curriculum development - Nanoliteracy

BACKGROUND, FRAMEWORK AND PURPOSE

Nanoscience and nanotechnology are often presented as a new scientific revolution or a new frontier to overcome that would generate tremendous economical gains (Roco, 2003). They also raise debates in society related to health and environmental issues, ethical concerns associated to modification of human beings and transhumanism, social and political issues linked to individuals data security and discussions about science and technology developments in democratic regimes (Berube 2006; David & Thomson, 2008; Lemley, 2005; Shapira, Youtie, Porter, 2010; Sheetz, Vidal, Pearson & Lozano, 2005). In such a context of controversial science and technology developments, education is presented as the major mode of science-society relationships regulation. Recent review of literature on nanoscience education has showed four emergent domains of interest for curriculum development and science education research (Hingant & Albe, 2010) : curriculum contents, approaches and purposes for nanoscience education at all levels of schooling, students' representations of size and scale and particularly nanoscale, specific instrumentations for nanoscience and nanotechnology teaching, science teachers training in nanoscience and nanotechnology. In this latter emergent research topic, this paper aims to contribute to our understanding of science teachers knowledge and representations about nanoscience and nanotechnology and their integration in science teaching.

RATIONALE

Literature on teachers professional development on nanoscience and nanotechnology has focused on the design and evaluation of training programs aimed to favour nanoscale science and engineering integration into teaching (Blonder, 2011; Daly, Hutchinson & Bryan, 2007; Hutchinson, Bryan & Bodner, 2009; Tomasik et al., 2009). Pre-post tests comparisons showed that teachers' knowledge improved a lot (Blonder, 2011; Tomasik et al., 2009) and two teaching strategies have been identified from teaching sequences produced by the teachers during training program : one consisted of integrating nano-related topics into the whole science curriculum and the other to add a specific nanoscience module into the curriculum (Tomasik et al., 2009). Teachers expressed more willingness to introduce an extension of the curriculum on nanoscience and nanotechnology rather than teaching a lesson on a completely new specific nano content (Daly, Hutchinson & Bryan, 2007). The introduction of nanoscale science into the curriculum is envisaged by teachers on a discipline base and interdisciplinary activities then seemed difficult to apprehend (Daly, Hutchinson & Bryan, 2007). Factors have also been identified for teachers' reasons to implement nanoscience lessons in class : relevance, student motivation, curriculum inflexibility, technical aspects and content knowledge (Hutchinson, Bryan & Bodner, 2009). Interviews with teachers showed that teachers were not at ease with students' questions in class and felt their scientific knowledge was not sufficient.

Teachers conceptions of nanoscale sizes have also been assessed by questionnaires and card sort tasks (Jones et al. 2008). Results showed that experienced and novice teachers' knowledge about small scale were poorly mastered. Experienced teachers better performed at nano-scale measurements than novice teachers. As we ever mentioned when reviewing literature, teachers nano related content knowledge needs research efforts (Hingant & Albe, 2010). In this context, the purpose of this paper is to document teachers' knowledge and intentions to teach nanoscience and nanotechnology. An empirical study was carried on before and after a one-week summer school on nanoscience and nanotechnology for French secondary science teachers.

METHODS

The 2010 E2phy summer school was the tenth issue of a series of yearly events dedicated to science teachers from secondary and higher education. It emanates from a group of teachers and researchers from research institutions[1], scientists and teachers unions[2] with the aim to promote scientific research, inform teachers of recent science developments and favor links between schools and research centers.

The 2010 summer school was focused on physics of the nanoworld. It included lectures on advanced domains in nanosciences, social impacts of nanosciences (ethic, health, toxicity, law, regulation-jurisdiction...) given by French researchers well-known in their respective fields, lab-work, visits of research centers and special events opened to a large public devoted to discussions on research in nanoscience and their societal impacts.

The science teachers attending the summer school knowledge on nanoscience and nanotechnologies and intentions to teach nanoscience and nanotechnology have been collected with pre and post questionnaires.

Questionnaires were structured into two parts : first on nanoscience and nanotechnologies and second on nano-education. First part consisted of five open questions (identical for pre and post tests) : According to you, what are nanoscience and nanotechnologies? What are the characteristics or specificities of nanoscience and nanotechnologies ? What do you think of the stakes, interests, strategies of research in nanoscience and nanotechnologies ?

Nanoscience and nanotechnologies developments raise debates, particularly on health and environment effects, did you hear about that ? According to you, what is debated ? What definitions of nanoscience and nanotechnologies do you give or would give in class ? Second part of the questionnaires consisted of four questions (identical for pre and post tests : What do you teach in nanosciences ? What curriculum contents do you think could be linked to nanosciences ? With what forms ? What finalities ?) and three additional open questions for the post-test to assess the summer school: what did you gain from the summer school ? What do you think you can integrate into your teaching ? On the opposite, what do you consider as poorly adequate for your teaching ?

125 questionnaires have been collected for the pre-test and 47 for the post-test. All answers were transcribed and coded with categories that emerged through 3 rounds of analysis. As a first step, two coders elaborated categories of answers independently, then confronted their categorisations to build consensus categories (second step). As a third step, the previously elaborated categories were revised through another round of coding. For statistical analysis, Sphinx software was used.

RESULTS

Science teachers' knowledge and representations on nanosciences and nanotechnologies

A large majority of teachers, both in pre and post-tests, consider that nanoscience and nanotechnologies are knowledge relative to the nanoscale, and for some teachers it is a new domain with specific applications. Characteristics or specificities of nanoscience and nanotechnologies from the teachers viewpoints also mostly concern the nanoscale then technological developments, and a link with quantum mechanics is underlined in the pre-test.

In the post-test, teachers also focused on new properties specific to this scale, raising technological difficulties and debates. Stakes and interests are focused in teachers responses to the pre-test on medicine, electronics and information technologies within the context of international competitiveness and on economical and social registers in the post-test.

Teachers were mostly aware of debates raised by nanoscience and nanotechnologies both in pre and post-tests. Teachers underlined mostly health, nano-particles toxicity and interactions with living organisms, and environment in a lesser extent in both pre and post-tests. Moreover in the post-test, they added legal, political, social and economical issues related to nanosciences and nanotechnologies. They underlined the absence of epidemiological results in the pre-test and mostly health and interactions with living organisms, and environment in a lesser extent in the post-test.

Science teachers' viewpoints on nano curriculum integration

Definitions of nanoscience and nanotechnologies to give in class are mostly focused on the nanoscale size and linked to knowledge on atoms and molecules for both pre and post-tests, and on the idea of a new domain with specific applications and physical properties in the pre-test (more rarely in the post-test for the latter). No answers of lack of knowledge were present in the post-test.

A majority of the teachers declared that at that time they don't teach nanoscience and cited curriculum contents that could be linked to nanosciences :

size and scale,
chemistry notions,

optics and medicine applications for the most cited (both in pre and post-tests) and electronics and size and scale in the post-test.

High-school teachers were the ones who contributed the most to the answers on that question about curriculum contents.

Forms of teaching envisaged are specific educative activities dedicated to the exploration and documentation of a new scientific domain in both pre and post-tests. Specific lessons in the science class are also mentioned in the pre-test according to the finalities of showing science in the making, developing engagement in science and understanding of scientific concepts.

In the post-test, collaboration with research labs, debates and video presentations are cited within finalities of showing science in the making, developing engagement in school science, understanding of scientific concepts, contributing to information literacy, citizenship education and learning to debate.

Teachers' evaluation of the summer school

In responses to the three additional open questions for the post-test, teachers expressed that from the summer school they gained knowledge on nanoscience and nanotechnologies and on nanoscience and nanotechnologies research, ideas for pedagogical activities and personal reflections. They considered that they can integrate informations and knowledge on nanoscience into their teaching.

CONCLUSIONS AND IMPLICATIONS

Pre-post tests comparison of teachers' knowledge show that nanoscience and nanotechnologies mostly defined a minima by the nanoscale size in the pre-test were also apprehended with specific physical properties and applications in the post-test. This result on teachers knowledge improvement through training programs converges with literature (Blonder, 2011; Tomasik et al., 2009). Teachers tend to favor specific designed teaching activities to integrate nanoscience and nanotechnologies in class. This result may converge with the previously identified teaching strategy of teachers privileging an extension of the science curriculum on nanoscience and nanotechnology (Daly, Hutchinson & Bryan, 2007) with reasons based on relevance, students motivation and content knowledge (Hutchinson, Bryan & Bodner, 2009). It also differs from literature stating a discipline base in teachers intentions (Daly, Hutchinson & Bryan, 2007) and on the opposite suggests an openness to curriculum activities in relation to educative aims broader than science concepts learning. This encourages to develop science education research linked to the design of teaching activities on a nano-literacy.

NOTES

1. National Institute of Nuclear and Particle Physics (IN2P3) of CNRS (National Center for Scientific Research, a government-funded research organization, under the administrative authority of France's Ministry of Research); French Atomic Energy Commission, leader in research, development and innovation, with the objective to ensure that the nuclear deterrent remains effective in the future.

2. The French Physics Society, association that aims to promote physics and physicists. Physics and chemistry teachers union, Teachers union in the French specific two years undergraduate programme leading to a nation-wide competitive examination into a French

"Grande école", leading schools in engineering, management, research... The scientific programme includes high level courses in mathematics, physics, chemistry, computer and engineering sciences, as well as humanities (foreign languages and philosophy).

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SCIENCE TEACHERS, POLICIES AND EDUCATION RESEARCH. ANALYSIS OF SURVEYS CONDUCTED IN SIX COUNTRIES

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Abstract: It is broadly agreed that the relationship between teachers’ beliefs and science education research results is complex and requires additional investigations and new approaches to understand the role of specific resources and constraints. Deeper investigation is needed concerning the distance among teachers’ feelings and expectations, the kind of educational research they know and the models of self-training that can be proposed in order to improve teacher knowledge and practice, supporting and focusing instruction in productive directions. The present research has been conducted, in the framework of the EU-funded TRACES project, in six countries (Argentina, Brazil, Colombia, Israel, Italy and Spain). Among all partner countries 1900 questionnaires were collected and 164 people (teachers, principals, researchers and policy makers) participated in interviews and focus groups. Findings from the comparison of the national surveys show the existence of tensions among all components of the education system. In the paper we analyze those concerning the relationships (and distances) of the school teaching from the national governance (guidelines, programs, assessment), on the one side, and educational research on the other side. Discussing the results we want to make a contribution to identify strategies and methods of investigation to figure out how to get answers to open questions of research that have not yet been sufficiently investigated.

Keywords: research-to-practice gap, evidence-based teaching, teachers’ beliefs, school system, education policies

BACKGROUND AND PURPOSE

An accumulating body of literature suggests that the gap between research itself and practice in science education is wide and rooted in a complex system of factors. In particular, we know that although teachers regard research evidence as valuable for they work, they are reluctant to adopt change if evidence does not resonate with their conceptions, beliefs and professional experience. The contribution we propose is the result of an international survey focused on the relationship between research and practice in science education undertaken in the framework of the TRACES project (see www.traces-project.eu), in which Italy, Spain, Israel, Brazil, Argentina, Colombia are involved. We use the findings from our surveys to identify key factors in the research-practice gap and suggest open issues and the way to address it in further research on the subject.

RATIONALE

Although it is well known that a deep gap separates educational research findings and real world school practice, research base about the links between aspects such as students performance and teachers’ preparation, beliefs and teaching approaches, resources available, interaction with principals, colleagues and pupils’ families, role of policies and curricula is still disparate and uneven (NRC, 2010; Lederman, 1999; Mellado, 1998). We know that research is crucial for improving science education (Duit, 2006). On the other side, fostering evidence-based change in teaching practice implies resonating with teachers' professional experience and beliefs about science education (Ratcliffe, 2005). Research findings are not likely to have an impact if they are not perceived as consistent with real-world practice conditions, such as availability of resources, average number of students per class, curricular constraints, teachers' pre- and in-service training. Bridging the research-practice gap in science education and sustaining the ongoing improvement in teaching and learning requires therefore more extensive investigation into all such aspects of the teaching reality. Recommendations and research agendas about a number of open questions for what regards improving evidence-based science teaching have been proposed in the literature (Osborne, 2008; NRC, 2010; NRC 2007). Further research is need on issues such as the relationship between different systemic factors in science education; how practice is influenced by policies, research and societal factors; how much policies are informed by research; how research-informed teaching improves students' performance; what is the role of teachers' beliefs and of their conceptions of science and pedagogy; what is the role of the context; what are the conditions that sustain or hamper effective teaching (see e.g. NRC 2011 and references therein).

METHODOLOGY

Our data include answers to a questionnaire administered to thousands of teachers in the six countries involved in TRACES and interviews and focus groups conducted with a smaller scale sample population of teachers, principals, policy makers, teacher educators and researchers in science education. The questionnaire includes both closed and open questions. A common form of the questionnaire was agreed at the consortium level. The common questionnaire was then localised – not simply translated – for application in each partner country. We considered that mere translation, rather than guaranteeing better comparability, would have provided less reliable data. In each partner country, some of the questions were adapted to the local context in order for the target group to understand their meaning as it was originally intended at the consortium level. The complete common questionnaire (in English) can be found in appendix to the report D3.1 on the TRACES website. The localised versions of the questionnaire can be found in the D2.1-6 reports. Our large-scale data include 1900 completed questionnaires, while on the small scale 164 people were involved. The detailed record per country is shown in Table 1.

	Argentine	Brazil	Colombia	Israel	Italy	Spain	Tot
Questionnaires	479	145	215	64	790	207	1900
Interviews / FG's	11	29	30	34	45	15	164

Table 1. Small- and large-scale survey samples in each partner country

Questionnaires have been assumed as the primary source of information, while interviews and focus groups represent a follow-up study, allowing for a deeper interpretation of the results emerging from the questionnaires. The comparison of the national surveys data started from identifying analogies and differences in answers to the teachers' questionnaire. The chart in Fig. 1 represents the overall answers to one of the core questions in the questionnaire (Q8: "In order to improve teaching and learning of science at school, do you think the following actions are?"), with agreement-disagreement with each item in the multiple choice measured on a 4-grade Likert scale.

As the chart shows, the majority of the teachers perceives all items in the multiple choice as at least relevant in order to improve science teaching, so expressing a strong need for structural changes in their extent practice. Nevertheless, a ranking in the importance attributed to the different actions is also quite evident. This ranking was quantitatively tested according to the non-parametric Mann-Whitney U-test. The main emerging issues can be summarized as follows:

a. Little relevance attributed to changes in curricula and official guidelines (item 1);
b. Little relevance attributed to changes in the assessment criteria (item 3);
c. Strong need for circulation of ideas and resources, but not for the involvement of external actors (items 2,8,9,10);
d. Strong need for material resources and in particular for lab facilities (items 11,12).

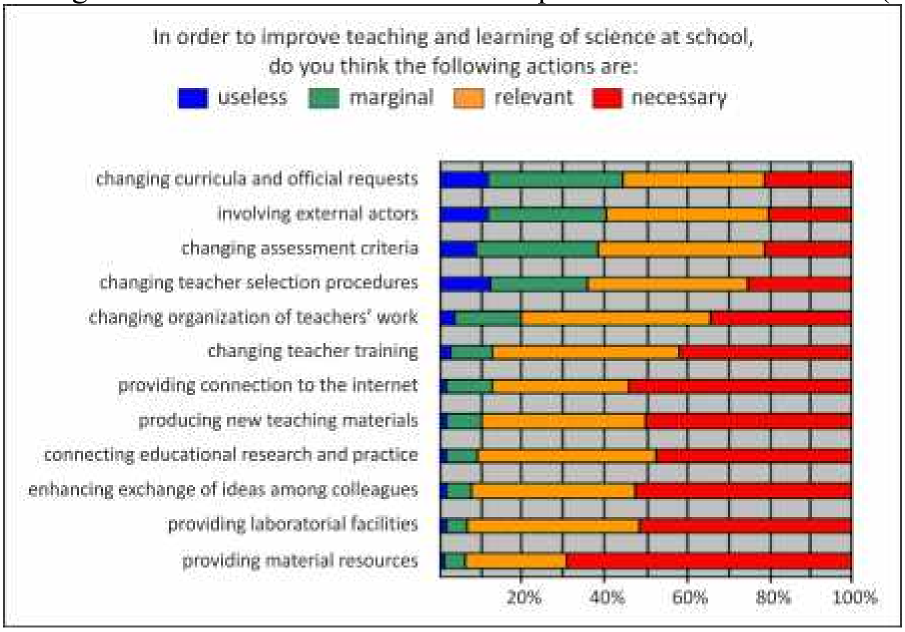

Fig. 1 Overall answers to Question 8 (large-scale sample)

These issues have been considered as emerging indicators of the tensions between teaching practices and policies (a., b.) on the one side and teaching practice and science education research (c., d.) on the other. Comparison of the qualitative data from interviews and focus groups allowed for a deeper insight into stakeholders' perspectives about elements a.-d. and an interpretation of the reasons of their emergence. In order to analyse these data, a qualitative content analysis approach based on text coding has been used.

RESULTS

In this paper, we discuss issues a.-d. listed in the previous section on the basis of findings from the main categories (occurrence above 10%) emerging from our text-coding analysis of qualitative data.

Tensions between educational policies and teaching practice

Teachers expressed low interest in "changes to the official requests" as a means for improving science teaching (a.). With slight differences in percentages from country to another, this item was one of the less valued in all our surveys. The emerging picture is confirmed when one cross compares these answers with those to Q1 (sources of the important ideas for science teaching) and Q9 (sources of ideas to improve teaching practice), in which the item "official documents" is very poorly represented (by far the less mentioned item with frequency lower than 10%).

In teachers' perspectives, the little relevance attributed to changing official requests is correlated to a number of factors. Teachers perceive a deep separation between the contents and goals of official documents and the real-world working conditions. Mostly, this is expressed with regard to lack of adequate time and material resources in order to fulfil the requests, or in terms of incapability of meeting students' needs related to a specific socio-cultural context. This remark is often connected to the lack of involvement in the design or evaluation of policies, referred to as one of the elements contributing to create the gap with the actual teaching practice.

Moreover, even if some teachers do value the rationale of official indications they often mention an absence of correspondent adequate training programmes. All the national surveys highlight teachers' general need for more specific training in order to be able to manage the contents of science curricula. Lack of specific training programmes developed to support the latest science education reforms is also referred to in almost all the involved countries. The perceived inadequacy of preparation often leads to a difficulty in complying to the official requests because they are poorly understood and hardly translated into practice.

The large majority of teachers seems to give prominence to practice as the main source of training (in the questionnaire, 77% of the sample indicates *professional experience* as the main source of inspiration for their teaching) and this habit is often translated into inertia in moving from a well-established practice based on experience and know-how.

Besides personal experience, a large majority of the sample in all countries referred to the enhancement of the exchange of ideas among colleagues as a strongly relevant change for the improvement of science teaching (Q8). This is also confirmed by answers to questions Q1 and Q9, in which colleagues are always referred to as one of the most valuable sources of ideas for science teaching.

At the same time, from interviews and focus groups emerges that the actual communication among teachers is often (perceived as) limited to issues related to the solution of organizational problems and institutional opportunities for dialogue usually do not foster a more significant interaction. Moreover, qualitative analysis (of both data from open questions in the questionnaire and from interviews and focus groups*)* suggests that the actual situation of practicing collaboration is rather more complex. Here, the attitude of everyone to question their own beliefs is considered as a necessary premise for a fruitful collaboration.

Another main issue emerging from the surveys is connected to structural barriers towards the improvement of science education that are characteristic of the national school organization. Among these barriers the more recurrent ones are the organization of teachers' work (mainly in terms of timetables), the lack of material resources, the lack of recognition and incentives, and the large number of students in the classrooms.

Interaction with school administrators is another point on which it is interesting to focus. Here, it is interesting to compare teachers' and principals' perception about structural issues. In both cases, a general perception of a strong lack of material resources emerges, with special reference to the lack of laboratorial facilities as crucial factor for the improvement of science teaching.

In all countries, principals also lament the lack of teachers' adequate preparation in scientific contents and teaching methodologies, together with the lack of motivation among teachers, which is seen as a factor opposing the implementation of innovation programmes. Teachers are seen as using out-of-date teaching approaches, mainly based on the use of textbooks as the main resource. The structural need for a better selection of teachers is connected to the limitations to their decision-making power.

The little relevance attributed to changes in assessment criteria (b.) is mainly correlated to negative perceptions of standardized evaluation tests. Indeed, a particular aspect in all stakeholders' perceptions – not only in the one of teachers – about the impact of official guidelines is connected with the introduction of standardized procedures for the assessment of learning, which is quite a topical issue in recent school reforms worldwide. There is almost general agreement in teachers' negative perception of this kind of tests as long as they expose to the risk of shifting the focus of teaching/learning towards the achievement of good results in the tests.

Tensions between science education research and teaching practice

In teachers' perspectives, the strong need expressed for the circulation of ideas and resources for the improvement of science teaching often refers to the importance of exchanging experiences with colleagues, seen as a means for collective growth. At the same time, from the questionnaires a judgement of poor relevance emerges for what regards the involvement of external actors. This is expressed by the large majority of the teachers in the sample (see Fig.1) (c.). This perception is again in line with the strong relevance of "professional experience" as source of important ideas for science teaching emerging from answers to Q1.

Putting all these considerations together, a picture emerges of teachers having strong confidence in their personal teaching skills. On one side, this could imply that teachers are interested in carrying out research autonomously in their schools, as is suggested by the fact that many among both teachers and other stakeholders in our small-scale sample referred to school as the place where research in science education has mainly to be carried out. Another possible interpretation, though, might be that that teachers see research finding mainly as teaching materials produced by research professionals they can profit from and use autonomously at school.

A finding that emerges clearly in all national surveys is that teachers would like to receive greater support from universities in order to improve their teaching practice. In teachers' answers to open questions in the questionnaire, and in interviews and focus groups, contact with research was frequently depicted as 'rare' or 'not common', while need was express for a stronger interaction between school and university. In fact, many teachers in our sample referred to research as a relevant transformational tool in their practice in the classroom, as it implies a direct impact on student learning. This is also confirmed by quantitative data on the relevance of enhancing "connection between practice and research" as a priority action in order to improve science education emerging from teachers' answers to Q8 (see Fig. 1). Nevertheless, we think deeper understanding is needed of the kind of contributions teachers expect from the interaction between school and university. At the same time, indeed, teachers often underestimate direct interaction with science education researchers, as is also evident from answers to Q8.

The reasons that are mentioned with highest occurrence refer to researchers' attitudes. Teachers depict researchers as lacking the capacity to actually manage the work in the classroom, mainly in terms of mediation strategies. Despite providing an important and necessary contribution in terms of disciplinary contents, researchers are seen as not having the necessary 'sensibility' for what concerns the dynamics of interaction and work with children. Moreover, one of the main and most widespread critical knots in the relationships between teachers and researchers seems lie in the teachers' vision that researchers are not sufficiently aware of school contextual matters and related constraints. Many teachers in our sample said researchers come to school in order to collect data for their publications and that scarce feedback is given for the school to actually be able to profit from.

When teachers refer to the importance of connecting their practice to the research evidence, they point out that their main interest seems to be directed towards educational tools and resources they can use autonomously.

By their side, researchers see the lack of interest towards collaboration as related to teachers' resistance towards didactic experimentation: teachers adopt innovation contributions only in very special situations, because experimentation leaves less room for the usual implemented curriculum, which is well inserted in the overall system and regulated by many factors, such as higher grades standards or internal surveys.

Moreover, it seems that some topical themes of research in science education play little role in teachers' interests. Generally, teachers underline the necessity to root practice in inquiry-based activities and to increase the material resources therefore necessary (d.). More precisely, many teachers mention the necessity of basing science education activities upon “practical work” and underline the importance of increasing the material resources devoted to this kind of activity. Nevertheless, a widespread view is that laboratories are a special context in which non-ordinary activities can be carried out. The whole idea of good practice in science education seems to be centred on the necessity of ‘practical’, ‘experimental’, ‘lab’ activities. These connotations are recurrent both in answers to open questions in the questionnaire and data from interviews and focus groups. The vision good practice appears indeed to be weakly connected with an inquiry-based approach, suggesting a naïve interpretation of hands-on work by the side of the teachers. Experimental activities are described as strongly based on pre-defined procedures, being often reduced to the mechanical repetition of a standardized set of manipulations. They often lacks of the direct participation of the pupils and aim more at obtaining ‘correct results’ than at comparing conflicting explanations or giving answer to any inquiry questions. This finding is in line with research conducted in other countries on science teachers’ belief on and implementation of practical work (see e.g. Millar 2010 and references therein).

Our data also suggest another facet of teachers’ perceptions of science teaching and learning. One that seems more aware of the cognitive aspects thereof. When asked about ‘important ideas about science education’ (Q1), teachers frequently refer to students’ thinking and reflection and when asked about the ‘most important goals of science education’, the majority of them rank critical thinking above learning for becoming a scientist or science for citizenship. In the case of teachers sharing this vision, emphasis is placed on the importance for students to learn to think and explain the way scientists do. Considerations of this kind of are indeed common cross-context and cross-nation in our data. There are although a few teachers who explicitly refer to thought processes that have been treated extensively in research on teaching approaches, like for example significant knowledge or teaching for understanding.

CONCLUSIONS AND DISCUSSION

Our analysis of a large amount of data collected in six countries as different as Argentine, Brazil, Colombia, Israel, Italy and Spain allows us to further detail some crucial open research questions and suggest specific aspects to look at in order to better understand the systemic features of the research-practice issue in science education. Findings emerging from our surveys highlight some of the factors underlying the tensions existing between three key components of the science education scenario: policies, research and practice. While some factors are common to the six countries involved, in other cases deeper insight is gained when comparing issues and strategies to address them in the different contexts. Based on our findings, we propose a research strategy for investigating open issues related to the research-practice gap. We suggest that an effective path is field research involving whole schools regarded as complex systems of interacting dynamics. In these programmes, teachers should be less the target of a ready-made intervention based on assumed research evidence than the protagonists of a participative process in which they work together with researchers as peers at all stages. Our findings sketch out a picture of teachers marked by a strong sense of isolation and scepticism towards policies and external actors entering the school. At the same time, a positive perception of research and innovation and a great need for change clearly emerge. Scepticism is a natural reaction when change is imposed top-down without debate, as is mostly the case of policies in the countries involved in our surveys, or when the interests of those promoting the change (e.g. researchers) are perceived as distant from one's own. Our findings lead us to believe that an in-depth inquiry into factors contributing to school's resistance to change cannot be addressed without an active involvement of those expected to be effected by the change. Based on the findings of our surveys, we have drawn up a set of indications for devising researchers-teachers interactions aimed at implementing research-based teaching (the complete set of indications can be found in D3.1, see above). Our field actions (now almost at the end of their one-year span in over 50 schools) are confirming that building trust is a process of mutual understanding and recognition which is based on a constant dialogue and exchange and participative decision making. That flexible structure and open-ended approach allow for an understanding of teachers' needs and expectations and the factors constraining their everyday practice. That this process is necessarily situated and context dependent as long as acceptance is based on the recognition that actions implemented are relevant to one's own practice. These findings support and widen the idea of "resonance" between research and practice as a key factor for bridging the gap as was suggested by Ratcliffe et al. (2005) and the considerations about essential elements in effective professional development emerging from the CASE project as reported by Adey & Serret (2010). Many of our findings are corroborated by the insights emerging in the framework of TRACES from analyses from other partner countries and presented in the common ESERA symposium. In particular, conclusions drawn by Israeli and Brazilian colleagues confirm our vision of the tension among policies, research and practice in science education and the need for a more active involvement of teachers and schools in research and development programmes. The question whether the role of researchers and teachers in common R&D programmes should be firmly distinguished based on the consideration that their competencies are structurally different remained open at the end of the symposium, with researchers from both the symposium panel and the audience holding different positions on the matter.

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PRACTISING SCIENCE TEACHERS' VIEWS ON CORES AND ITS IMPACT ON THEIR PROFESSIONAL KNOWLEDGE OF PRACTICE

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Abstract: This paper reports on a research project that explored the use of CoRes with in-service secondary and primary teachers in Australian schools. The two year longitudinal study investigated how these teachers (n = 6) might *value* CoRes, after constructing and using them in their classrooms, and how the instrument might influence or develop their long term professional practice. In particular, the project explicitly explored how their PCK might be articulated, revealed or developed as a consequence. In constructing and using CoRes in their classrooms, all six teachers claimed that the CoRe was a considerably valuable instrument in helping them to frame their knowledge of practice more explicitly, that they began to articulate and form an understanding of their own PCK, and that the CoRe prompted them to meaningful reflect about their practice in more deliberate, conscious and effective ways.

Keywords: Content Representations (CoRes). Pedagogical and Professional-experience Repertoires (PaP-eRs). Pedagogical content knowledge. Science teacher education. Science teachers' knowledge.

BACKGROUND, FRAMEWORK AND PURPOSE

Pedagogical content knowledge (PCK) has long been an attractive construct for educational researchers since its conception over twenty-five years ago (Shulman, 1986). PCK received much attention, particularly within science education research, because it presented a new way of conceptualising, acknowledging and viewing a distinct and specialised form of teachers' knowledge. PCK brought together the idea that, as part of their professional knowledge of practice, the teacher linked content knowledge together with knowledge of pedagogy in sophisticated and complex ways which meaningfully enhanced student learning (Loughran, Berry, & Mulhall, 2006).

While the academic world has engaged in ongoing and largely theoretical discussion about that which encompasses PCK (Kind, 2009), it is difficult to find accounts of its value and use for teachers in practice. Abell (2007) called that more PCK research on teachers in practice was needed: "It would benefit the research if conceptual frameworks were made explicit. … More studies need to focus on the essence of PCK – how teachers transform SMK [subject-matter knowledge] of specific science topics into viable instruction …" (p. 1134). Specifically, within the realm of science education, Van Driel (2008) called for effective ways of developing science teachers' PCK, particularly because "science teachers often have problems to transform their content knolwedge into a form which is appropriate for the specific target group they teach" (p. 1).

In responding to these calls, science education reseachers Loughran, Berry and Mulhall (2006) developed CoRes as one such framework. CoRes were intended to engage teachers actively in the process of learning about their own practice, and in drawing out their tacit practices and expert teacher knowledge in ways that would begin to articulate and portray instances of their individual and unique PCK. Importantly, CoRes deliberately attempted to capture the complex knowledge of the teachers' thinking and reasoning behind and about the content of a specific science content area and the choice of pedagogical activities that would be best suited for their particular students.

In this way, CoRes seemingly offerred a way of conceptualising PCK into a usuable construct into the real world of teacher practice, and therefore offered a new way of viewing the theory-practice gap (Korthagen & Kessels, 1999; Pekarek, Krockover, & Shepardson, 1996). It is hoped then, that as practicing science teachers' use CoRes in their practice, that the theoretical construct of PCK becomes a more explicit, substantive and valued part of their professional knowledge and provides them with a common langaugage in which they can easily share their PCK with colleagues (A. Bertram & Loughran, 2011).

This research study therefore tested CoRes with practicing science teachers ($n = 6$). The main purpose of the research was to explore these teachers' views on using CoRes in their practice. The two year study explored:

- how CoRes might be *valued* by these teachers;
- how the process of creating one and using it in their practice might, if at all, have influenced or developed their professional knowledge of practice;
- if they felt it caputured or portrayed instances of their PCK; and finally,
- how their individual understanding of PCK might have developed as a consequence.

RATIONALE

In the science education research literature, CoRes have been favourably reported on as an effective instrument in capturing and providing reified examples of science teachers' PCK (Kind, 2009). Yet few studies exist where they have been tested and validated with practicing teachers. This study takes the important step of "testing for applicability" in the classroom and seeks to validate or test CoRes with practising science teachers over a two year period.

METHOD

This research involved six practising teachers in a longitudinal, ethnographic study (cf. A. R. Bertram, 2010). At the start of the study, the teachers were individually interviewed and asked to describe their current views on teaching and learning. The construct of PCK was then explained to the participants and they were introduced to the framework of CoRes. Participants were then expected to develop and produce their own CoRe based on a science unit or topic that they would soon be teaching. Soon after this stage, the participants were interviewed for comment on the process of making it and how this process might, if at all, have influenced their thinking about teaching and learning, and in particular, how it might begin to reveal and/or develop aspects of their own PCK.

In due course, participants taught the topic or content on which their CoRe had been based. Again, participants were interviewed to explore their views on the impact, if any, that the CoRe might have had in the teaching of the topic. About a year later after using the CoRe in their practice, participants were interviewed to provide their post-intervention views on teaching and learning. These views were contrasted with their pre-intervention views and participants were asked to consider if any changes might have been influenced by using the CoRe in their practice. This final interview also considered the participants views' on the long-term impact or influence which CoRes might have had on their professional practice, and in particular, how they might have, if at all, developed their own PCK.

The major source of data collection for this study came from individual interviews at each stage of the research. The open interview format allowed teachers to offer narrative accounts which enriched the data and provided great insights into their thinking (cf. Clandinin & Connelly, 2000; Conle, 2003). However, a weakness of the reliability and validity of this methodology might be that much of the data relies on self-report. Therefore some degree of triangulation was embedded into the research design to limit these weaknesses and to provide credibility. The teachers' CoRe itself became a data source which was used to reinforce the reliability of the teachers' narrative accounts and the extensive and longitudinal nature of the interviewing process supported the consistency of the teachers' ideas and views over the length of the study.

RESULTS

All participating science teachers claimed and endorsed CoRes as being an effective instrument which helped them to better understand their professional knowledge of practice. On a general level, all participants believed that CoRes offered them a structured and meaningful means of reflection which forced them to reflect in a purposeful and deliberate manner. Individually though, the CoRe each brought out something different about the practice of each participant. For three of the participants, they felt that it made them rethink their general understanding of what "teaching" and "learning" meant to them on a personal level. For three other participants, they claimed that the CoRe impacted the way they understood the term "student learning" and it caused them to think more carefully of how their particular students' understood the content being taught.

All participants (none of which had an understanding of PCK prior to this study) agreed that the construct of PCK, *as developed through their CoRe,* offered teachers' an important and useful construct for shaping their professional knowledge. For the participants themselves, they now had an instrument which had provided concrete forms of instances of their own PCK. All participants believed that by having an awareness of these instances, and in the process of making the CoRe - the deliberate questioning and reasoning about the content and the pedagogy forced by the CoRe's prompts – improved their understanding of teaching and learning and impacted their long-term knowledge of practice.

The researcher also noticed that the teachers, at the post-intervention stage, now had begun to develop a shared language of communicating their PCK and ideas about teaching and learning with others.

While the participating science teachers' views of CoRes support that it is indeed an effective instrument in articulating and developing PCK and that it would be extremely useful for the professional teacher, there was a major limitation to its design. All participants stated that an enormous investment of time was required for its production; and not one of the participants could see themselves using it in their own practice of their own volition. Two participants suggested that perhaps, CoRes be embedded into the curriculum practices of the school.

CONCLUSION AND IMPLICATIONS

This research study provides some evidence that CoRes provoked participants to think beyond their normal approach to practice. It also gave them a vehicle from which they could reframe their views in line with a (developing) PCK perspective. In essence, all participating science teachers' claimed that CoRes positively influenced their professional knowledge of practice and enhanced their understanding of PCK. Hopefully, this study has verified to some degree that CoRes offer a valid means for which the academic concept of PCK may be actualised in practice, thereby reducing the theory-practice gap and presenting exciting new possibilities for research into the important area of that which constitutes practicing science teachers' professional knowledge of practice.

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DIAGNOSTIC COMPETENCIES OF PRE-SERVICE TEACHERS ANALYSED BY MEANS OF THE SIMULATED SCIENCE CLASSROOM

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Abstract: Pedagogical diagnostic competence (PDC) is one of the main professional skills of teachers. It is a fundamental precondition to identify students' difficulties in learning or their shortcomings in knowledge, which is fundamentally important precondition though a teacher will be able to select appropriate feedback and actions to support the students' learning. Beyond that, the teachers' PDC is the requirement necessary for the fair judgement of students' performances. However, it seems to be difficult to ascertain PDC in the context of teaching, because in authentic teaching situations the influence of confounding variables can hardly be controlled. By employing a specifically adapted computer program – the "Simulated Science Classroom (SSC)" – it is possible to create teaching-analogue situations in which parameters of achievement and motivation of "simulated students" can be controlled systematically. In experimental studies we investigated specific components of "science related pedagogical diagnostic competence (SPDC)" of 80 pre-service chemistry teachers taking over the role of a chemistry teacher interacting with 12 simulated students. The analyses show that the examinees were able to compose an approximately correct ranking of the simulated students' achievements, but the levels as well as the standard deviations of the simulated students' achievements were systematically underestimated by the examinees (in all of the four different experimental treatments we investigated).

Keywords: Diagnostic achievement competencies of (pre-service) teachers, Simulated Science Classroom, Science Learning Achievement, Performance Assessment

INTRODUCTION: BACKGROUND, FRAMEWORK, AND PURPOSE

It is considered extremely difficult to systematically conduct research on diagnosing competency in an educational context, since the number of distracting variables in authentic classroom situations are almost impossible to control. Using a specially developed computer programme, it is possible to simulate classroom-like situations and to systematically control the performance parameters of simulated students. In this way, the classroom situations – albeit that they are simulated – allow for the possibility of using experimental studies to conduct research on pedagogic-diagnostic competencies of (pre-service) teachers regarding their ability to assess the performance of (their) students. – Together with the taskforce "Psychology for Pedagogues" at the University of Kiel, a research group in Freie Universität Berlin's Department of Chemistry Education has developed a set of virtual scenarios which simulate classroom situations in science lessons of grades 5/6.

This article will introduce the development of the computer programme used to simulate these science lessons as well as the first results of our experimental studies with 80 pre-service chemistry teacher students.

RATIONAL – CURRENT RESEARCH

Aside from being able to show the necessary leadership qualities in the classroom as well as pedagogical skills and knowledge of the subject, a teacher's diagnostic competency plays a significant part in the development and success of lessons (Helmke, Hosenfeld & Schrader, 2004). Diagnostic competency is, in essence, the ability to fairly judge a student's performance (Schrader, 2006). However, diagnostic competency can also include the ability and knowledge to enable teachers to appropriately make these judgments – amongst others methodical knowledge (e.g. knowledge and command of diagnostic methods, knowledge of judgment errors and tendencies) and subject-specific knowledge (e.g. the expectations in a specific area of learning or the difficulties of certain tasks). On top of that particular awareness plays a significant role (e.g. awareness of particular students and classes, e.g. their strengths and weaknesses and the difficulty and popularity of particular subject areas in these classes).

Previous research on teachers' diagnostic competency has focused primarily on the accuracy of diagnostic assessments of written tests. Studies compared teachers' assessments as regards different student traits with the "actual traits" – surveyed using standardised tests. The interpretation of the data is usually restricted to a measure of congruence – correlating calculations between teacher assessment and trait manifestation. According to Helmke and Schrader (1987), three components must be considered when analysing the accuracy of teachers' assessments:

- the *level*,
- the *differentiating* and
- the *rank component*.

The *level component* is a measure of the assessment of the absolute level of a student trait. The *differentiating component* shows whether dispersion of the student trait has been overestimated or underestimated. Finally, the rank component determines whether within a particular class the teacher has correctly determined a rank of the students' performances.

Until now, only few studies on the diagnostic competency of teachers considered all three of these components of diagnostic assessment. If the level of a student's performance is taken into consideration when investigating the accuracy of performance assessments then the results often show an overestimation of student performance (Artelt, Stanat, Schneider & Schiefele, 2001; Bates & Nettelbeck, 2001; Madelaine & Wheldall, 2005). On the other hand, there is usually an underassessment of the dispersion of student performance (Helmke et al., 2004; Helmke & Schrader, 1987), while the rank component is reported as satisfactory (Demaray & Elliot, 1998; Egan & Archer, 1985; Feinberg & Shapiro, 2003; Hoge & Butcher, 1984).

According to this, teachers assess the rank of student performances relatively well. But, all the aforementioned studies focused on the analysis of test subjects' diagnostic qualifications, as determined by written data of student performance (e.g. written tests or examinations).

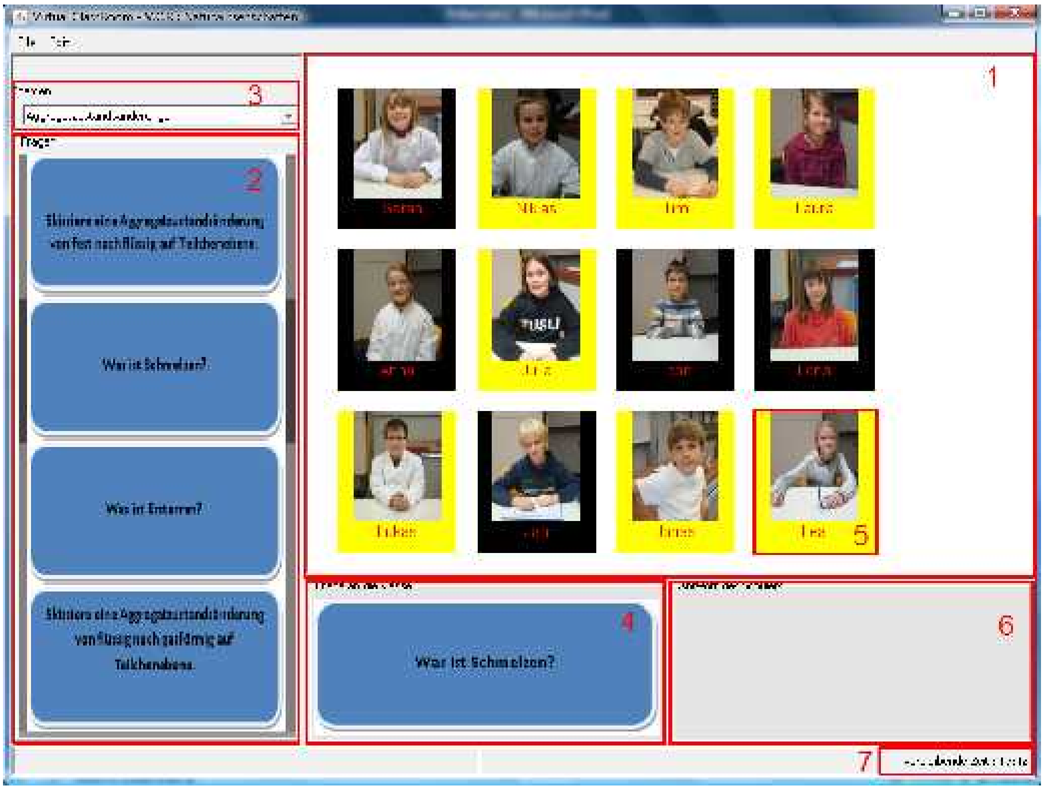
However, *how is the diagnostic competency of the (budding) teachers affected when the assessment of student performance is solely based on their oral participation in class as this is the case in most school learning situations?*

Scientifically, this question has proven difficult to answer.

METHODS

The Simulated Classroom (SCR)

The paradigm of the simulated classroom is a method well suited to experimentally investigate diagnostic competency (Fiedler, Freytag & Unkelbach, 2007; Fiedler, Walther, Freytag & Plessner, 2002). The method comprises a computer simulation of a classroom, in which the user (examinee) takes on the role of teacher and proceeds to interact with virtual students (see picture 1; no. 1); leading to the assessment of experimentally steered student performance, for example.



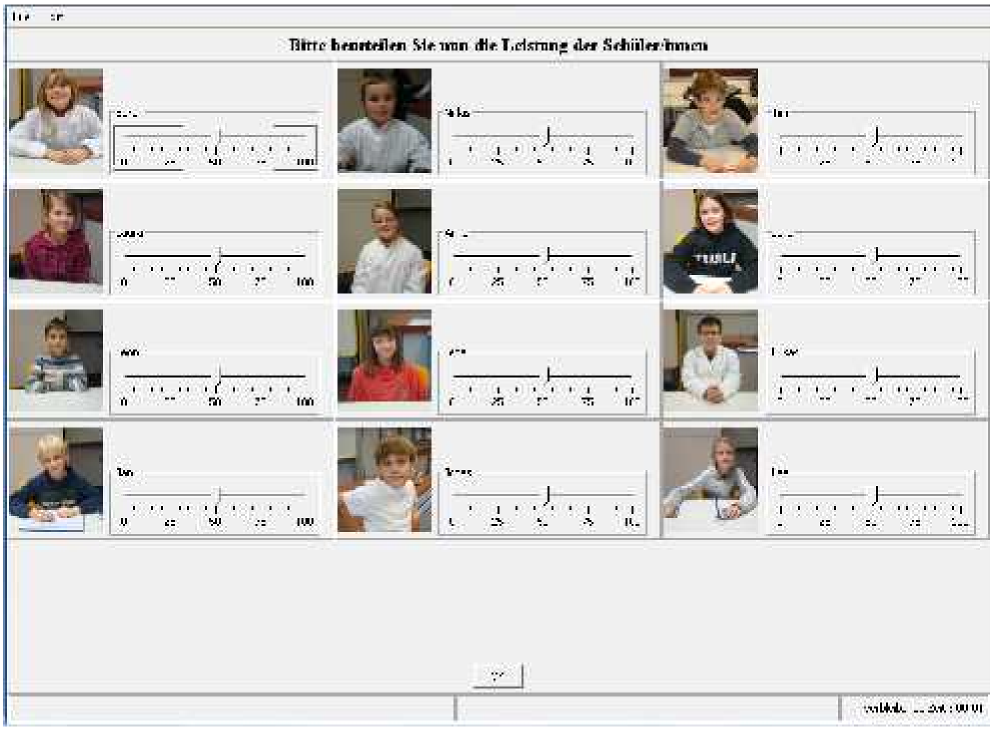
Picture 1. Screen of the simulated (science) classroom

During the Simulated Classroom settings the examinee chooses subject specific test questions (see picture 1; no. 2) from a list f topics and contents (see picture 1; no. 3) and directs them at the simulated students (see picture 1; no. 1). The selected question appears on the screen (see picture 1; no. 4). Now, some of the simulated students (pictures) appear in a yellow frame symbolizing that these students show up to give an answer (see picture 1; no. 5) to the selected question (see picture 1; no. 4). These yellowed framed simulated students can be asked by the examinee to give the answer. The student answer than appears and is to read in the “answer-frame“ on the screen (see picture 1; no. 6). This answer will be a correct or an incorrect one which is to recognize by the examinee reading and assessing the student answer (and/or by looking on the picture background of the answer which is green in the case of a correct student answer or red in the case of an incorrect respond).

This procedure can be repeated and is to repeat till the simulated lesson is over; in our study a simulated lesson takes 18 minutes. Last but not last, the examinee can see the remaining lesson time of the simulated lesson by means of the “time-frame” (see picture 1; no. 7).

After the simulated lesson the examinee has to assess the performance of each student, first on a scale from 0 to 100 and last but not least by a six-point-rating-scale.

The number of correct answers by the individual simulated student represents his/her performance ability. The performance parameters of the simulated students are selected and fixed by the examiner before the testing of the examinees and – of course before – the investigation of their ability to assess the simulated students' performance.



Picture 2: Screen of the students performance assessment in the simulated (science) classroom

The correlation between the students' performance and their assessments by the examinees can be interpreted as the diagnostic competency of the examinee-sample.

The simulated classroom can act as a tool for the experimental investigation of different questions with regard to teacher, student and classroom research. Apart from the students' performance abilities, a wide range of other student traits (such as motivation skills, social interaction, socio-cultural background) can be simulated and investigated regarding their effects in teachers' assessment processes. This is particularly interesting when looking to conduct research on different and specific diagnostic competencies. Nevertheless, the overall aim should be to portray the classroom situation as socio-ecologically valid as possible, while at the same time allowing the investigation of experimentally exaggerated questions with high internal validity.

The Simulated Science Classroom for Years 5/6

In the course of adapting the programme to incorporate science educational research, the working group agreed on first concentrating on science classes grades 5 and 6 (in German: Naturwissenschaften 5/6). The questions and the anticipated right and wrong student answers, which were developed as part of this project, have been taken from other empirically tested instruments. By means of these instruments students' conceptions and misconceptions concerning specific science concepts (e.g. the particle model of matter or concepts of inquiry) were analysed (Benedict & Bolte, 2008; Erb & Bolte, 2009). The analysed student answers build the basis for the stimulated student answers in the simulate science classroom (see picture 1).

The research question of this – as far as we know – first science educationally weighted study is:

In how far are (budding) chemistry teachers able to assess and judge student performance in the lesson correctly?

The simulated classroom of science classes in grades 5/6 was designed and realized in two different versions. In this publication we will focus only on introducing the results of the version that ignores the influence of the subject content knowledge of the examinee. This concentration on only one treatment version has been chosen for better comparability with the setup of the previous studies we are referencing at (Spinath, 2005; Südkamp & Möller, 2009; Südkamp, Pohlmann & Möller, 2008).

Furthermore, aside from the three assessment components mentioned above (see level, differentiating and rank component) a fourth component, the global degree of variation component – developed and introduced by Südkamp (2010) – will be included in our analysis.

Two questions (which are more methodological in nature) form the core of our experimental study:

1. Are there statistically significant differences in test subject performance (here: chemistry teacher students) in terms of the four selected assessment components between the examinees in this study and those examinees of other studies which were conducted with the help of the simulated classroom? (effect of the subject and the students PCK pedagogical content knowledge)
2. What are the differences in the examinee' diagnostic performance between test run 1 and 2, if they are asked to complete two test runs with the help of the simulated classroom for science in grades 5/6? (training effect)

RESULTS

First Investigations Using the Simulated Classroom

In first investigations using the simulated classroom (SCR) conducted by the working group of the taskforce "Psychology for Pedagogues" at the University of Kiel, Südkamp and Möller (2009; see also Südkamp, Pohlmann & Möller, 2008) were able to show evidence regarding the instrument's validity (Südkamp, 2010). Furthermore, the teacher students they investigated by means of the SCR were able to form a rank of student performance within a class. However, the absolute level was overestimated by the Kiel examinee, while the dispersion was underestimated by them.

Results from the Study using the Simulated Classroom of Science in Grades 5/6

In the research context of science education a sample size of 20 chemistry teacher students was used for the first test run. The results regarding question 1 and 2 are listed in Table 1.

	Bolte et al. (2010)	Spinath (2005)	Südkamp et al. (2008)	Südkamp & Möller (2009)
Rank component	0,40; 0,26	Median: 0,40	0,62; 0,68 0,54; 0,53	0,64; 0,66
Level component	-0,07; -0,09	0,03	0,04; 0,03 0,09; 0,07	0,07; 0,09
Differentiating-component	0,79; 0,71	0,84	0,76; 0,92 0,74; 0,81	0,81; 0,82
Global degree of variation	0,17; 0,19	./.	0,20; 0,15 0,21; 0,20	0,20; 0,19

Table 1. Results of the analysis of diagnostic competency – differentiated by assessment component and (reference) study

CONCLUSIONS AND IMPLICATIONS

In our opinion, the results obtained with the help of the simulated science classroom grades 5/6 are comparable to the results obtained in the reference studies. Noteworthy is the fact that with regard to the results of the rank component, the examinees of the science educational study do not quite reach the level of the examinees in the reference studies. Striking is the drop in performance of the chemistry teacher students (examinees) in the second test run. Interesting and worth mentioning is also the finding that the examinees of the science educational study underestimate the performance level of the simulated students – to our knowledge this effect has not been shown in other studies before.

Further investigations conducted by Bolte, Köppen, Möller and Südkamp should and will show whether these peculiarities and potential discrepancies are a coincidence or whether they have systematic causes (Bolte, Köppen, Möller and Südkamp, in process).

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DIFFERENT MODELS AND METHODS TO MEASURE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE

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Abstract: This Proceeding will explore the theoretical underpinnings of the construct of PCK as researchers are currently using it. Five speakers will provide perspectives on the overall problem; the theoretical conceptions, measurements, and results used within specific research groups; and provide a synthesis of the research while engaging the audience in discussion.
To consolidate different point of views on PCK, we have selected researchers who use more qualitative methods such as interviews and open-ended questionnaires as well as researchers using more quantitative methods, such as open-ended and multiple-choice items for large-scale paper-and-pencil-tests. This symposium will also be interdisciplinary, connecting biology, chemistry, and physics PCK research, thus shining a rare spotlight on PCK in the natural sciences.

Keywords: Pedagogical Content Knowledge, qualitative methods, quantitative methods, natural sciences

DEVELOPMENT OF THE CONSTRUCT PEDAGOGICAL CONTENT KNOWLEDGE

Background

Teachers' professional knowledge may be considered the single most important characteristic in instruction. Elbaz (1983, p.11) points out that "the single factor which seems to have the greatest power to carry forward our understanding of the teacher's role is the phenomenon of teachers' knowledge." To categorize this knowledge, Shulman (1987) distinguished seven categories: content knowledge; curricular knowledge; pedagogical content knowledge; general pedagogical knowledge; knowledge of learners and their characteristics; knowledge of educational contexts; and knowledge of educational ends, purposes and values. Ever since Shulman established these categories, many researchers have come to believe that pedagogical content knowledge (PCK) is an important topic in science education, and that high levels of PCK will predict high levels of student achievement (Abell, 2007). However, research has not yet produced a general consistent model or measuring method of PCK (cf., Park & Oliver, 2008; Fischer, Borowski, & Tepner, in press).

In recent research there are two different approaches to model PCK. Some researchers see PCK as was introduced by Shulman: an integrative knowledge category (Gess-Newsome, 1999). This view of PCK includes an 'amalgamation' of other knowledge categories (e.g., content knowledge and general pedagogical knowledge [Shulman, 1987]) with a particular inner knowledge part.

Using this definition of a PCK model, Baumert et al. (2010) showed a high correlation between PCK and content knowledge, even though content knowledge and PCK are separate categories that can be empirically distinguished.

From another point of view, PCK can be seen as a separate category of knowledge with its own unique identifiers (cf., Magnusson, Krajcik, & Borko, 1999). These models are called transformative models of PCK (Gess-Newsome, 1999), because in these models, PCK can be seen as a transformation of knowledge from other knowledge categories (e.g. knowledge of science curricula, understanding of science, instructional strategies and assessment of scientific literacy [Magnusson et al., 1999]). Both approaches to PCK models agree that the knowledge of representations of subject matter and instructional strategies incorporating these representations, and additionally, the understanding of specific student conceptions and learning difficulties are important facets of PCK (Park & Oliver, 2008).

Numerous methods of measuring teachers' pedagogical content knowledge have been developed since Shulman introduced teachers' pedagogical content knowledge: interviews, paper-and-pencil tests for theoretical knowledge, paper-and-pencil and video vignettes for reflective knowledge, teacher training as an intervention and video observation of real instruction, and, very commonly, a combination of two of these. The research studies using these methods can be divided into two groups: small-scale and large-scale assessments.

In small-scale studies, paper-and-pencil tests and a quantitative analysis of video observations cannot be used because psychometric criteria cannot be achieved. On the other hand, in large-scale studies, intervention and interviews cannot be used because the workload is too much.

At the beginning of PCK research intervention, an observation or intervention and interviews were used to investigate PCK in small-scale studies (cf. Lee & Luft, 2008, van Driel, Verloop, & De Vos, 1998). The aim of these studies was not to measure PCK, but to validate models of PCK (cf. Park & Oliver, 2008). Recently, more quantitative studies have been accomplished based on these small-scale studies. More generalizable results about PCK and the connection to other knowledge categories, as well as the connection to the students' outcomes were and will be produced in these large-scale studies (cf. Baumert et al., 2010). A result of the large-scale studies is, for example, that teachers with a higher PCK score create better lessons, which has a positive effect on the students' content knowledge test results. (Baumert et al., 2010).

So four key divergences in the PCK literature exist:

Nature of PCK: What assumptions exist for PCK as an attribute of teachers? Is it an unalterable characteristic or does it changes with experience and/or particular kinds of preparation or professional development?

Model of PCK: How is PCK related to the professional knowledge base for teaching? Is it transformative or integrative?

Measurement of PCK: Is PCK a knowledge base, an artifact of practice, or both? What are the appropriate levels at which to measure PCK? Should it be examined at the topic level (e.g., mechanics) or the domain level (e.g., physics)?

Contexts for Studying PCK: Where should the emphasis of PCK research lie? Should it be studied in terms of the translation of teacher knowledge to practice, or in terms of the relationship between teachers' level of PCK and student outcomes?

The goal of this session is to use these questions to analyze the positions taken by the three research groups while grounded in a broader analysis of the field.

MEASURING PHYSICS TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE (SOPHIE KIRSCHNER, ANDREAS BOROWSKI, HANS E. FISCHER)

Nature of PCK: The aim of the study is to find important components of PCK which have a big impact on the students learning progression and motivation. And after that these components shall be integrated in the education of student teachers. So the assumption of the study is that PCK can increase with **professional development**.

Model of PCK: Teachers' professional knowledge, which describes the competence in teaching a given subject, has long been recognized in literature as an essential variable for fruitful teaching (Abell, 2007). In order to analyse professional knowledge, it can be broken down into different categories. Recent research (e.g. Baumert et al., 2010) defines three common categories: pedagogical knowledge (PK), pedagogical content knowledge (PCK) and content knowledge (CK). The categories contain many features of Shulman's original seven categories but are differently arranged (Shulman, 1987). PCK is the dimension that only teachers – here physics teachers – have and need. As PCK characterises teachers, is specific for single domains (cf. Park & Oliver, 2008) and is a great predictor of student achievement (Baumert et al. 2010), this presentation will focus on this knowledge category.

Measurement of PCK: In this project, PCK is operationalized as a **knowledge base for teaching** with the help of a three dimensional model. The model covers (1) different knowledge areas, (2) themes and (3) facets.

(1) The knowledge areas are divided into three levels: declarative knowledge, procedural knowledge and conditional knowledge (Paris et al. 1983). The reaction to critical teaching situations can be found in this last area. This was tested with vignettes describing a short situation in a classroom, often in the form of a script. We used some of these for the PCK test, but remain aware of the problem that it is difficult to reliably code the answers and to ascertain that the tested teachers focus on the "right" problem.

(2) The content of the PCK, CK and student tests is mainly related to the topics of **mechanics**, **electricity**, but also contains **physics in general**. Mechanics is part of the curriculum in all German secondary schools.

(3) We use three facets for the PCK test: experiments, teaching strategies and students' preconceptions. Students' preconceptions are important in physics teaching (Duit & v. Rhöneck, 2006) while experiments play an important role in physics lessons. Concepts are a connection between students' preconceptions and experiments: A teacher has to understand physical concepts to decide how to present a topic in a way students can understand it and to avoid deepening their misconceptions. All three facets can be found in the Magnusson model (Magnusson et al., 1999) as knowledge about areas of student difficulty, representations and activities. According to Park & Oliver (2008), it can be assumed that expertise in these facets is important for successful science teaching.

Contexts for Studying PCK: The study is part of a bigger project (Borowski et al., 2010), which investigate the **professional knowledge** of biology, chemistry and physics teachers and its influence on the respective teaching/learning process in class and **the achievement and motivation of students** in science. In the first step the professional knowledge of the teachers is being measured subject related by paper-and-pencils-tests. In the next step teacher knowledge will be measured, their lessons will be videotaped and the science knowledge and motivation of their students will be tested.

Rationale

The COACTIV Study (Baumert et al., 2010), in which mathematics teachers' knowledge was assessed, shows different PCK values for teachers of different school types. The goal of this study is to validate a model, using a related test instrument that has to show on one hand, similar results for in-service physics teachers with similar teacher education (convergent validation), and on the other hand, differences between physics teachers and other groups (pre-service teacher, non-physics-teachers and physicists) who are expected to obtain lower PCK values (discriminant validation).

Methods

PCK was operationalized by using the model described in the section called measurement. The PCK test for physics teachers consists of 17 items. Open-ended and multiple-choice questions were used in the test. The answers were evaluated with a coding-handbook.

N=167 physics teachers located in two different federal states of Germany were tested. Their average age was 44 years (SD=9.9); 29 % were female. The teachers were from different secondary school types in Germany (Bonsen, Bos & Frey, 2008): 137 of them teach at a Gymnasium (GY), 30 at lower level school tracks (NGY). To validate the test, 21 math teachers were tested. The participants completed the test voluntarily in sessions that lasted 50 minutes for this test. They were guided by a supervisor. The entire PCK test has an acceptable Rasch reliability (.76).

Results, Conclusions and Implications

Teachers who did not study or teach physics got poor results, which confirm that the test is able to measure knowledge that is not pedagogical knowledge, general knowledge or abstract thinking. Physics GY teachers were shown to have a significantly higher PCK than teachers teaching at lower level school tracks (NGY), M_{GY}=66.0, SD=15.2, M_{NGY}=44.2, SD=15.8. The significance $p < .001$ was calculated with a T-test, the effect size is large ($d = 1.41$). Of note here is that teacher requirements at different school types in Germany differ widely: Teachers at Gymnasium spend more time at university, and there are differences in the content in teacher education at university, depending on what kind of teacher they are training to become. The results indicate that we are able to measure knowledge that is based on university studies and can be influenced by teacher training. The differences give a first hint that PCK and CK are linked because GY teachers spend more time on learning physics but not on learning pedagogical content.

A valid topic-specific, large-scale paper-and-pencil model for pedagogical content knowledge has been developed. The test, which operationalized the theory-driven model, shows the expected results, which signalizes in sum that we are in fact measuring PCK.

The connection between teachers' test values, their teaching observed by videotaping and their students' knowledge, interest and motivation will be analyzed next. After this, the facets, knowledge areas and topics which are most important for student achievement can be dissected further. In the future, this test can be used to assess physics teachers' theoretical PCK to obtain more generalizable results. These domains will need to be examined in more detail in further studies, which may lead to changes in teachers' education and training and, at a theoretical level, to more focused models for future studies.

CONCEPTIONS OF PEDAGOGICAL CONTENT KNOWLEDGE (JANET CARLSON, JULIE GESS-NEWSOME)

The Nature of PCK: The ultimate goal of teaching is enhanced student learning. We propose that teachers apply two knowledge bases to teaching. The first knowledge bases are academic in orientation. Teachers gain this knowledge through careful study. The knowledge lends itself to measurement through multiple means, including paper and pencil tests. Of Shulman's (1986) proposed **knowledge bases for teaching**, we selected academic content knowledge, knowledge of general pedagogical strategies and skills, and knowledge of the learner as the most relevant to classroom practice. Pedagogical Content Knowledge (PCK) is second knowledge base for teaching. It differs from the academic knowledge bases in that it is **dynamic**, integrates the other knowledge bases, and must be assessed when planning, enacting, or reflecting on teaching.

Model of PCK: PCK is the melding of subject matter expertise with pedagogical strategies and knowledge of the learner to produce high quality classroom practice. PCK is a unique knowledge base held by teachers that allows them to consider the structure and importance of an instructional topic, recognize the features that will make it more or less accessible to students, and justify the selection of teaching practices based on student learning needs (Shulman, 1986). With PCK, neither content knowledge nor generic teaching skills alone are sufficient to be an effective teacher. Our **integrative** definition of PCK includes the sub-components: *Content knowledge* including depth, breadth, and accuracy of content knowledge; connections within and between topics and the nature of science; and fluency with multiple modes of representation or examples of a topic. *Pedagogical knowledge* including a rationale linking teaching strategies to student learning; strategies for eliciting student prior understandings; and strategies to promote student examination of their own thinking; and *Contextual knowledge* including understanding of student variations, such as student prior conceptions, impact instructional decisions

Measurement of PCK: The following assumptions on teachers' professional learning guide our work: (1) Teachers knowledge exists on a **continuum** from weak to strong. (2) Teacher knowledge can be strengthened through preservice preparation programs, inservice professional development, and high quality curriculum materials. (3) Teachers with stronger knowledge bases are better able to improve student learning. (4) Teachers' professional knowledge bases are related to each other, classroom practice, and student learning. (5) PCK is **topic specific** and can vary by topic. A teacher may have high PCK for "carrying capacity" and a low PCK for "protein synthesis." As a result, PCK cannot be effectively determined at the level of "biology."

Contexts for Studying PCK: In our theory of action, we propose that **interventions**, such as professional development, **influence teacher knowledge** bases. These knowledge bases include academic content knowledge (ACK), general pedagogical knowledge (GenPK), and content-specific PCK. We hypothesize that these knowledge bases are related to each other and influence **teacher practice** to become more inquiry-oriented, resulting in greater **student achievement**.

Rationale

The goal of this study was to examine the construct of PCK and how PCK changes in teachers as a result of an intensive professional development and the use of highly educative curriculum materials.

Methods

Our data comes from a study of 40 self-selected high school biology teachers across one state. Participants complete a two-year professional development experience to become familiar with high quality curriculum materials, deepen content knowledge, and expand understanding of effective pedagogy. Over the two years, participants implemented the curriculum, attended five weeks of intensive (40 hours/week) summer professional development, and participated in five days of collaborative lesson study and the examination of student work.

Results

PCK varied by topic. In an analysis of sub-scale MFTB scores at the baseline, percentage correct across the five subscales varied as much as by 61% and as little as 8% (X=32.17%, *sd*=12.77%). When comparing PCK scores across topics using the highest scores in any one sub-topic, scored for an individual varied by as little as 2% and as high as 54% across topics (X=18.42%, sd=11.51%). Clearly, ACK and PCK scores are topic specific.

The *correlation analysis of teacher variables* suggests that they are generally related to one another with most correlations statistically significant. In particular, ACK is not fully distinct from PCK-CK (r = .65, p = .004) but appears to be more distinct than any of the other teacher variables because it is significantly correlated *only* with PCK-CK. In addition, despite being discrete in our theoretical model, PCK-CK and PCK-PK are strongly related (r = .64, p= .004).

Relationships between Teacher Knowledge (ACK, GenPK, PCK-CK, and PCK-PK) *and Teacher Practice* were tested using ordinary least-squares multiple regression. Despite being generally correlated, the teacher variables are not correlated strongly enough with one another to constitute a multi-collinearity problem in the multiple regression analysis. Teachers with higher GenPK and PCK-CK scores exhibited more inquiry-based teaching practices (GenPK, t=3.75, p<.01; PCK-CK, t=2.06, p=.059). No statistically significant relationships were found between either ACK or PCK-PK and Teacher Practice.

Student achievement scores increased significantly from pre-test to post-test for all subscales. We used hierarchical linear modeling (HLM) to *determine the amount of variance in student achievement scores accounted for by teacher knowledge bases and practice* in Years 1 and/or 2. Only teachers' ACK accounted for a significant amount of the variance in student achievement (t=2.18, p=.054). The relationship between Teacher Practice and Student Achievement was not statistically significant, indicating that Teacher Practice is not a mediator of any of the teacher knowledge bases.

Discussion, Conclusions, and Implications

Participants made positive and significant gains in all of the knowledge bases across the program. While there was not a relationship of ACK to teaching practice, increased ACK was associated with greater SA. PCK-CK increased from the baseline to later time points in the program and was positively and significantly related to classroom practice but not SA. These results are complicated to interpret when compared to other studies. When ACK is measured through proxies such as courses taken and grade point average, the relationship to SA is less than 1%. Direct measures of ACK have positive and significant relationships to SA (Baumert et al., 2010; Hill et al., 2005), as supported by this study.

In Baumert et al. (2010), ACK was related to PCK-CK, as was the case in our study, and PCK-CK had a positive impact on SA in their study while in ours it did not.

While increases in GenPK and PCK-PK over the project are supported by our data, the impact of this knowledge on practice varies, with a positive and significant impact from Gen PK but a non-significant impact from PCK-PK. Neither GenPK, PCK-PK, nor Teaching Practice was significantly related to SA. The results may be explained by the mechanical implementation of the curriculum and school-based variables, including testing, that detracted from the implementation of new inquiry-oriented practices.

When considering PCK, the teachers in our study claimed that all parts were important. While ACK laid the foundation for teaching, growth in PK was perceived to be stronger during the project. Our quantitative data supports growth in all areas, though only GenPK and PCK-CK had a significant impact on teacher practice. While we would have hoped to see a stronger impact of the knowledge of student learning (PCK-PK) on classroom practice, this is an area that teachers' admitted to having limited knowledge of and experience with, and it represented a dramatically new way of thinking about their teaching.

DEVELOPMENT OF EXPERIENCED SCIENCE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE (INEKE HENZE, JAN VAN DRIEL)

Nature of PCK: While PCK has been a subject of research since the 1980s, and much has been written about its importance as a foundational knowledge base for teaching, little is known about the process of PCK development, especially in experienced teachers and in the context of educational innovation. Up to now, few empirical investigations have been conducted into how different aspects of this knowledge are connected and may **influence each other's growth**.

Model of PCK: In the present study, we defined an PCK as teacher knowledge about (a) instructional strategies concerning a specific topic, (b) students' understanding of this topic, (c) ways to assess students' understanding of this topic, and (d) goals and objectives for teaching the specific topic in the curriculum. In this, we largely followed the categorizations of Grossman (1990) and Magnusson et al. (1999, p. 99). Compared with Shulman's original construct (Shulman, 1986), these authors adopted a somewhat broader definition of PCK. Acknowledging that the various components of teachers' PCK may interact in very complex ways, Magnusson et al. (1999) claimed, "Effective teachers need to develop knowledge with respect to all of the aspects of pedagogical content knowledge, and with respect to all of the topics they teach" (p. 115). So the study has a **transformative** view on PCK.

Measurement of PCK: This study focused on the relationship between parts of teachers' PCK and their experience in teaching PUSc. So in this view PCK is a **topic specific** knowledge base for teaching that can expand for each topic.

Contexts for Studying PCK: The study investigates the **translation** of teacher knowledge to practice. For that we followed nine teachers for a period of three years in their natural settings to see if, and how, their initial PCK developed while they were teaching a new subject. The innovation in this study concerned the introduction of Public Understanding of Science (PUSc.) as a new science subject in secondary education in the Netherlands. Among its other objectives, the new syllabus is intended to make students aware of the ways in which scientific knowledge is produced and developed.

Students should gain a clear understanding of a scientist's activities, for example, designing and using models, developing theories, and carrying out experiments (De Vos & Reiding, 1999).

Rationale

The aim of this study was to investigate the developing PCK of a small number of experienced science teachers in their first few years of teaching the new syllabus on Public Understanding of Science. We aimed to identify the content and structure of their PCK of a specific topic in the PUSc. syllabus, namely, 'Models of the Solar System and the Universe', describing its development in terms of relations between its different components (Magnusson et al., 1999). We did not intend to describe in detail the PCK development of each individual participant, but to identify possible common patterns across the knowledge development of different teachers (Verloop, Van Driel, & Meijer 2001).The following research question was central to the study: How can science teachers' PCK of the specific topic of 'Models of the Solar System and the Universe' in the PUSc. syllabus be typified at a time when they still have little experience of teaching PUSc., and how does this PCK develop when teachers become more experienced in teaching this particular topic?

Methods

The study was conducted among nine PUSc. teachers working at five different schools. The nine teachers responded to a written invitation we sent to ten different schools using the same teaching method. The teachers varied with regard to their backgrounds, years of teaching experience, and original teaching disciplines. Among the participants were three teachers of physics, three teachers of chemistry, and three teachers whose original discipline was biology. Their teaching experience ranged from 9 to 24 years at the start of the study. To become qualified to teach the new science subject, the teachers had taken part in a one-year course, which was conducted nationwide. They were all among the first PUSc. teachers at their schools.

With all teachers, a semi-structured interview was held in three subsequent years, immediately after the teaching of a chapter on the solar system was finished. The interview questions were developed on the basis of the results of a study of the relevant literature on PCK, on the one hand, and models and modelling in science and astronomy education, on the other hand.

Results

As a result of the analysis of the interview data from the first year, we identified two types of teachers' PCK of 'Models of the Solar System and the Universe'. These two types were considered as different starting points for the development of teachers' PCK in subsequent years. Type A of PCK appeared to be focused mainly on model content, while Type B of PCK was focused on model content, model production, and thinking about the nature of models. We compared the answers and reactions of the nine teachers with the characteristics of Type A and Type B, and as a result we considered the PCK of five teachers to be more or less indicative of Type A, while the PCK of the other four teachers was classified as representative of Type B. Type A could be typified as mainly oriented towards the teaching of science as 'a body of established knowledge', while Type B could be typified as more oriented towards the teaching of science as 'experiencing science as a method of generating scientific knowledge' (Hodson, 1992).

From our results, we conclude that in the development of PCK of Type A, some of the elements of PCK (especially knowledge about instructional strategies) become more sophisticated or expanded, however, the interaction between these elements was rather static. With regard to the development of PCK elements of Type B over the years, we conclude that changes in the knowledge about instructional strategies, the knowledge about students' understanding, and the knowledge about assessment were mutually related. Teachers' knowledge about goals and objectives of the learning and teaching of 'Models of the Solar System and the Universe' did not change significantly, that is, not only the visualization and explanation of phenomena were still emphasized in this PCK element, but also how to formulate and test hypotheses, and how to obtain information about phenomena.

CONVERGENCES AND DIVERGENCES IN THE CONCEPTUALIZATIONS OF PCK

Current Divergences in the Study of PCK

Frustrated by research findings that revealed weak or inconclusive links of teachers' content knowledge to student achievement, Shulman (1986) proposed a "missing paradigm" in educational research, pedagogical content knowledge. PCK challenged past practices of examining knowledge of subject matter and pedagogy separately. Instead, PCK recognizes the melding of subject matter expertise with pedagogical strategies and knowledge of the learner to produce high-quality classroom practice. PCK is a unique knowledge base held by teachers that allows them to consider the structure and importance of an instructional topic, recognize the features that will make it more or less accessible to students, and justify the selection of teaching practices based on student learning needs. With PCK, neither content knowledge nor generic teaching skills alone are sufficient to be an effective teacher.

Nature of PCK: Until very recently most PCK research has been devoted to describing strong instances of the construct using qualitative research methods (Research Group 3). Such studies have focused on the characteristics within and between teachers. As these studies do not directly address the origins of teacher PCK, or assumptions made about those origins, some reviewers of this research may draw the conclusion that PCK is an inherent characteristic that teachers either possess or do not possess. Other research efforts build on the recognition that classroom practice has a major impact on student success, and rely on the assumption that teacher actions result from teacher knowledge and beliefs (Research Groups 1, 2, and 3). From this foundation, additional hypotheses follow: PCK exists on a continuum from weak to strong, PCK can be strengthened, and teachers with strong PCK are better able to improve student learning. There is mounting evidence that PCK exists on a continuum, both across and within teachers, and influences teaching practice. Working from the assumption that depth of content knowledge is a precursor to PCK, early studies examined the differences between teachers. Some examined teaching practice resulting from different teacher preparation programs (Research Group 1). These studies demonstrated that depth of content knowledge resulted in differing teaching practices, providing initial support for the PCK construct. When examining the development of PCK over time, the results are mixed. Early studies show that PCK develops with the experience of teaching a topic multiple times. Research Group 2 and 3, when studying the impact of professional development on PCK, reinforces this work. Examining student work or elucidating misconceptions are particularly effective means of increasing teachers' careful consideration of content and pedagogical knowledge on classroom practice.

Model of PCK: Building from earlier work and applied to the field of science, Magnusson, et al. (1999) developed a model of PCK. PCK included orientations to teaching (such as inquiry, didactic, and conceptual change) that shaped and were shaped by knowledge of science curricula, knowledge of student understanding of science, knowledge of instructional strategies, and knowledge of assessment of scientific literacy. This model of teachers' professional knowledge defines PCK as a separate and distinct knowledge base with its own unique identifiers. Gess-Newsome (1999) termed this model transformative, meaning that PCK is the product of the transformation of other unique knowledge bases for the act of teaching. In this perspective, the characteristics of PCK such as teacher orientation to teaching science, knowledge of science curricula, and so forth, are transformed into a new knowledge base defined as PCK. This PCK "inside the box" is dynamic and less prone to sub-categorization. For researchers examining PCK from this framework, PCK can often be defined as almost anything that a teacher knows, believes, or can do when thinking about or engaging in the act of teaching. Research Groups 1 and 2 fall into this category. For other researchers, PCK is the integration of the professional knowledge bases, which can be measured individually and within PCK. In this case, PCK is integrative (Gess-Newsome, 1999). Research Group 2 falls into this category. In this case, academic knowledge of content (measured by multiple-choice tests), general pedagogical practices (such as pacing and classroom management), and the ability to list student misconceptions can be contrasted with that knowledge that exists within PCK. PCK is measured through teacher planning, reflection, and practice, and is compared to the other knowledge bases.

Measurement of PCK: The existence of different PCK models has resulted in different tools developed and used to measure teachers' professional knowledge as well as the use of different types of analysis for the data collected. For example, when PCK is considered as transformative, many aspects of PCK can be measured, but they generally culminate in a single PCK measure (Research Group 1 and 3). When PCK is considered as integrative, questions about the relative value of the components of PCK to each other and their relationship to "external" knowledge bases become of interest (Research Group 2). This study was purposeful in identifying attributes of PCK and studying the psychometric properties of the definition. While there is generally a lack of consensus regarding the appropriate level of analysis for PCK, all three Research Groups included in this symposium studied PCK at the topic level. In mathematics, PCK is frequently studied PCK at the domain level - mathematics (Baumert et al., 2010).

Contexts for Studying PCK: Some studies on PCK have focused on the relationship between teachers' PCK and their other knowledge bases and practice. Others have targeted the relationship between teachers' PCK and student achievement. Only Research Group 2 took this approach. The relationship between teacher variables of academic content knowledge, pedagogical knowledge, and PCK is similar to the finding of Baumert et al. (2010). Their results differ in that teacher variables other than academic content knowledge were not related to student achievement. Fewer studies address the contention that teachers with strong PCK are more likely to increase student achievement. Research Group 1 addresses this question by examining teachers in different career stages, working from the assumption that more experienced teachers will possess greater levels of PCK, though student achievement results are not included.

Conclusions and Implications

Research on the nature of teachers' professional knowledge, in general, and PCK, in particular, is a topic of great interest to the science education community. While the past 20 years has generated a wealth of data that has the potential to improve teacher preparation with the goal of increasing student achievement, the variety of definitions and tools for PCK limits our ability to create a strong research base. Conversations across research groups, such as this one, are vital if consensus on the construct is to be reached, or if purposeful variation in the research is to be embraced. This symposium represents an initial attempt to find points of convergence across researchers, and determine fruitful avenues presented by the divergences in research agendas. Our hope is to create stronger synergy in our research definitions, tools, methods, and assumptions so that we might improve teacher knowledge and practice.

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THE PEDAGOGICAL CONTENT KNOWLEDGE OF SECONDARY SCHOOL PHYSICS TEACHERS ON ELECTRIC FIELDS

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Abstract: This study examines the initial characterization of the Pedagogical Content Knowledge (PCK) on electric fields of four Colombian secondary education physics teachers. The results revealed four factors that mediate their personal teaching models: their interpretation of the institutional curriculum; the time available to develop the theme in class; the relationship between physics and mathematics; and the consideration of the most effective strategies for teaching physics.

Keywords: Pedagogical content knowledge, secondary school physics teachers, electric field

THEORETICAL FRAMEWORK

For science teachers, the core of their professional development has to be science education itself, since the content to be taught conditions both the teacher's role and the teaching strategies used (Abell, 2007). According to Shulman (1986), teachers develop a body of knowledge about teaching the content – Pedagogical Content Knowledge (PCK) – which is specific to each subject, is elaborated personally in the course of their teaching practice, distinguishes teaching as a profession, and is a form of reasoning and pedagogical action by means of which they transform the content of the subject into representations that are comprehensible to their students. PCK is knowledge that is constructed with its own particular sources, components, nature, filters, and structure (Morín, 1992). From the range of models that describe PCK, the present study assumes that proposed by Friedrichsen et al. (2009) because of the orientations it provides for science teaching, an element that permeates and influences all four components of PCK: knowledge of the curriculum, of instructional strategies, of the pupils, and of evaluation.

Our focus is the topic of electric fields, since this is recognized to be a concept that pupils find hard to learn and understand (Furio & Guisasola, 1997, 1998, 2001; Llancaqueo, 2003). The prevailing teaching itineraries have favoured teaching strategies that proceed from the simplest phenomenology to the more complex (Colombo de Cudmani & Fontdevilla, 1990), i.e., from electrostatics to electric currents, ignoring the part played by the electric field in this transition. Altering this view will involve a profound revision of the teaching models that physics teachers have built up over the course of their classroom practice, both in their initial teacher education and in their professional career. These changes have to start from the knowledge and reflection on what teachers think and do in teaching this concept, combined with their active participation in a process of metacognitive reflection (Mellado et al., 2006)

THE RESEARCH PROBLEM

The research question we set ourselves was: *What is the initial PCK of secondary education physics teachers in Colombia on the concept of the electric field?*

METHODS

The participating teachers were three men and one woman physics graduates, with a mean age of 26 years, and between 3 and 7 years teaching experience. The ages of their pupils ranged between 17 and 19 years.

The study was organized into three phases – documentation, action, and reflection – in which each teacher was to perform a specific task. Each phase was designed as part of qualitative research from a perspective of hermeneutic phenomenology.

The data collection and analysis procedures were: (i) an open choice questionnaire inquiring into what the teacher believes to be the teaching strategies in physics and the role of planning in the teaching and learning process; (ii) the curricular materials the teachers used; (iii) the planning template proposed by Pro (1998); and (iv) the matrix designed by Loughran, Berry & Mulhall (2004) to represent content (ReCo), to which some modifications were made in the number of questions and the form of selecting the core ideas on teaching electric fields.

RESULTS

All the teachers reduced the core ideas proposed for teaching electric fields to electric force, charge distribution, geometric representation of the field, and field intensity. However, they each focused on some subset of these ideas on which they proposed most of their activities.

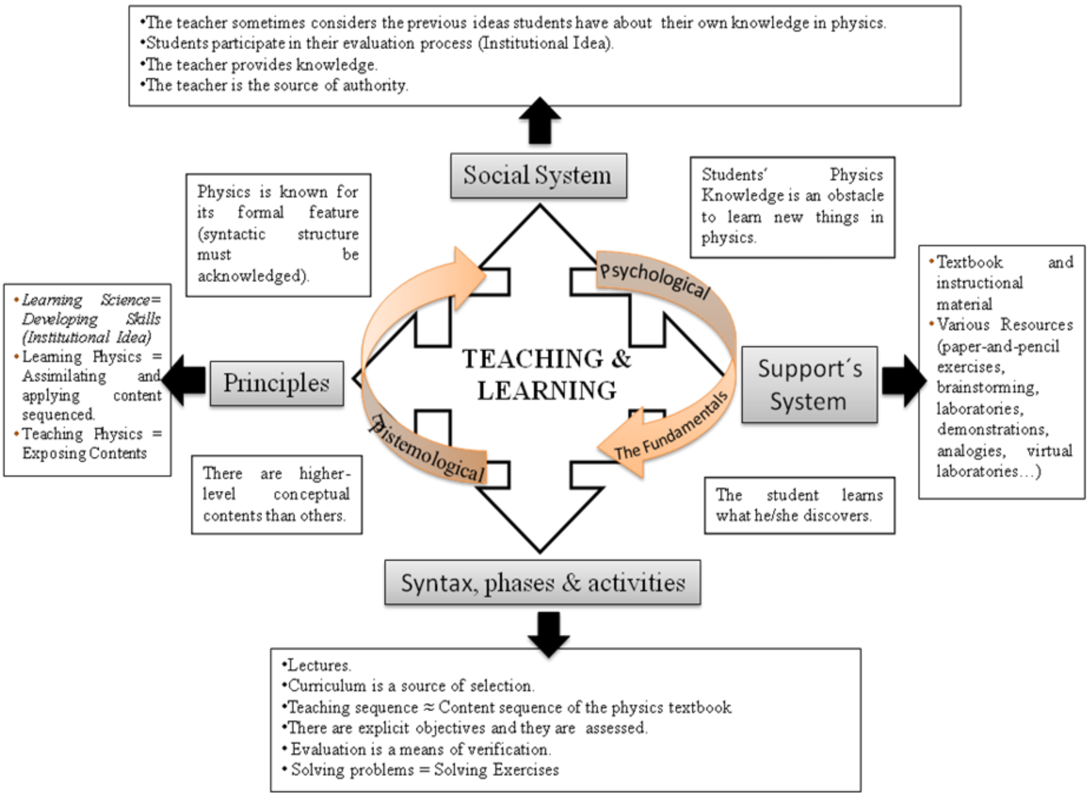
Teacher 1 showed a structure of physics which requires mathematics to be understood. This meant that he emphasized ideas involving the use of algorithms such as the electric force and field intensity, and exercises of application. He also considered that the greatest difficulty the pupils find in understanding the topic is in doing the exercises involving mathematics.

Teachers 2 and 3 focused on the geometrical representation of the field in space, with a view of physics as an interpretation of the world in the form of models. Hence most of the problems or exercises they set had to do with the use and interpretation of lines of force.

Teacher 4 planned his classes around the idea of vector field, as is proposed by the school in which he works. He presents the topic as one more application of this general concept. Although he also presents the idea of physics followed by Teachers 2 and 3, his emphasis in teaching the electric field corresponds more to the idea of physics of Teacher 1. This perhaps reflects this teacher's internal debate between what is required by the institutional curriculum that he has to follow and his own ideas about physics and teaching.

All four teachers centre their teaching on conceptual and procedural content, setting aside in their teaching goals and purposes aspects that are attitudinal or relative to citizenship education. The teachers' stated objectives were both general and specific to the topic. In all cases, these objectives constituted the key criterion mediating the evaluation process, whose character was always as a check of the pupils' learning.

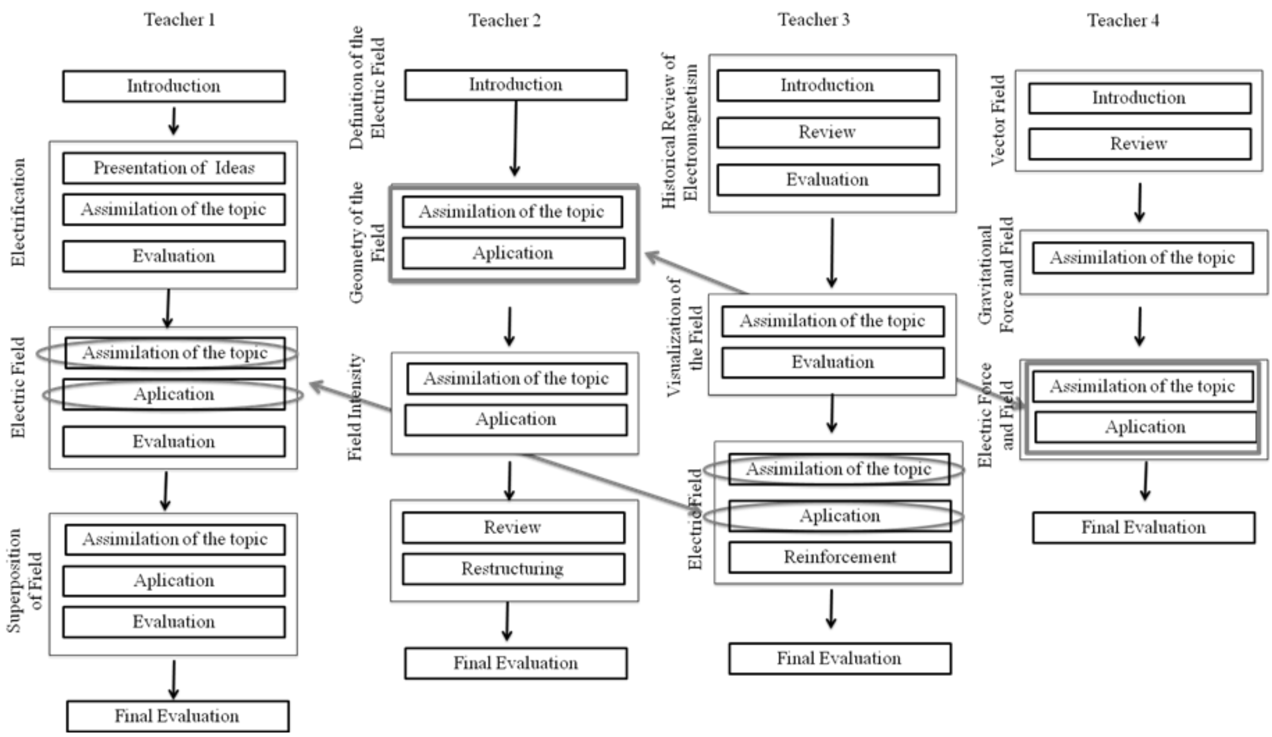
Figure 1: Teacher 1: Teaching and Learning Ideas



The nuances of the traditional model adopted by Teacher 1 (Figure 1) were due to the idea of physics that he fosters together with his role in the classroom. For Teacher 4, it was due to the form in which he implements his school's policies. For Teacher 2, it corresponded to the strong emphasis placed on the time available to work on the topic. For Teacher 3, there was no overriding reason.

The teaching sequences followed by the four participants were extracted from the analysis of instruments (ii) and (iii) (see Methods above). They all proceed by starting with an introduction, followed by a space for the pupils to assimilate and apply the topic, and end with a final evaluation of the unit (Figure 2). The sequences comprise successive blocks which describe how the teacher plans to teach each item of the content linked to understanding the concept of electric field. Teacher 1 repeats microsequences in which the pupil assimilates the subject matter, applies it, and is then evaluated. Teacher 2 prefers blocks in which the pupil only assimilates and applies the topic, leaving the evaluation to the end of the unit. Teachers 3 and 4 use different microsequences for each item of the content. To conceptualize electric fields, all the teachers choose a sequence in which the pupil assimilates and then applies the topic.

Figure 2: Features of the four teahcer´s intructional sequences



CONCLUSIONS

There was a general consensus on which content to teach on the concept of electric field. Teachers 1 and 4 keep to the traditional teaching itinerary used in the university education of physics teachers: they proceed from the phenomena of static electrification until they arrive at the concept of electric field, or they define what a vector field is, and then consider the electric field as a mere application of that definition. Teachers 2 and 3 see physics as an interpretation of the world in the form of models, and consider that the pupils need to visualize the field in order to understand the concept, for which reason they change the order of the content to teach.

All the teachers believed the most effective activities in teaching physics to be pencil-and-paper exercises, the teacher's presentation, and laboratory work, regardless of the teaching and learning paradigm the teacher followed.

The factors which condition their personal teaching models are their interpretation of the institutional curriculum, the time they have available to develop the topic, their ideas on the relationship between physics and mathematics, and their consideration about what is the most effective strategies for teaching physics.

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PRELIMINARY STUDY OF TEACHERS´ VIEWS ON SCIENCE EDUCATION IN PRIMARY SCHOOL OF SALTA (ARGENTINA)

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Abstract:

It is presented a progress report with results of a research experience that explores teachers´ thinking about factors that improve and those that threaten good science education in elementary schools in Salta (northern Argentina). Data arise from a survey´s application and interpretation of a questionnaire assumed as an introductory inquiry designed in a more global Research Project (TRACES). A total of 3500 surveys were distributed and a 14% of them answered it. The present report focuses on the answers to questions 6 and 8 of the questionnaire. Conclusions remark specific responses on the pursued factors.

Keywords: teachers´ thinking, elementary school, influential factors, educational research-teaching practice gap

INTRODUCTION

The TRACES Project, Transformative Research Activities. Cultural Diversities and Education in Science, funded by the European Commission under the Science in Society action of the 7th Program, promotes transformative research activities to investigate the factors that contribute to the research-practice gap, with the aim of proposing guidelines for innovative policies in science education that can contribute to fill that gap. In this Project, desk and field research are being combined in a cyclic process of analysis, action, reflection involving both researchers and teachers.

In particular, we are investigating the effectiveness of research based science teaching (Ratcliffe et al, 2005) facing learners' diversities in terms of individual, cultural, linguistic, gender-related factors.

The first phase of TRACES is a field survey to draw a significant picture of all main actors´ perceptions and opinions about the research - practice gap in science education. In each of the partner countries – Italy, Spain, Israel, Argentine, Colombia and Brazil – researchers have developed a 18-item questionnaire applied to teachers of grades 1-10. It focuses on aspects of science education such as availability of resources, interaction among colleagues, pre and in-service training, gender difference, its relationship to research in education. As Ratcliffe et al (2005) say, teachers in science education “recognize and make use of research findings in the course of their normal practice”. In this sense, Jones & Carter (2007) develop a socio-cultural model from which teacher´s beliefs about practice is embedded by perceived social norms when implementing an instructional design. Even though, Lederman (1999) states that “results indicate that teacher´s conceptions of science do not necessarily influence classroom practice”.

Partially based on these findings, present report is part of the survey developed by researchers from the National University of Salta, carried out in northwestern Argentina.

The objectives for the application of the questionnaires are:

a) Recognition of opinions to identify parity or difference between those assumed as critical factors in science teaching arising from the inquiry from those so declaimed by the research literature.

b) Promoting conceptual and strategic hints in relation to public policies and curriculum to take into account in teaching, with the purpose of enhancing science education in primary school.

METHODOLOGY

It is applied a survey protocol (14 questions) adapted from the original format developed by TRACES Project. Local institutional features are considered and adjustments arise from the pilot test realized before the general application of the final instrument. From the total number of teachers of the province (11.174 teachers), the survey is applied to a sample of 3500 school teachers: from the Capital and inner urban, suburban and rural areas; of unique staff school and plurigrade classes' teachers; from state and private schools; teachers who attend lower, medium and high social class´ students, including those coming from native ethnic groups. Responses obtained (478) reach almost 14%. The analysis is made on the answers to questions 6 and 8.

Question 6, *"How positively or negatively influence your teaching each of the following?",* investigates teacher's opinions on the influence of topics from a didactical/professional, socio-cultural and institutional points of view. Referring to specifically didactic issues it is asked on: textbooks, assessment and learning subsunsors. Referring to professional issues it is inquired on training and mastery of content.

Question 8 *"How do you think are the following actions for the purpose of improving teaching and learning science in school?",* investigates topics seen as contributions of teacher's professional practice. Finally, this question aims to recognize the importance of teaching and oriented curriculum policy in a Latin America context.

Questionnaires were distributed by the Post Office service. However, responses were submitted to the will and commitment of School officers and to the interest of the surveyed teachers. Nevertheless, the number of questionnaires received in the mailbox of the Project was really interesting.

The answers obtained were charged into a computational system specially designed for the purpose of collecting and analysis of data.

Following section tables and graphics demonstrate data analysis emerging from research task and its interpretation.

RESULTS

Collected 478 questionnaires, a general overview led to realize a general comprehension of its contents. From this early analysis it was possible to find out a set of categories which allowed classifying the given written answers. One of the main categories is related to didactical issues, the other refers to professional development.

The didactical issues point to teacher´s beliefs about the sense in which resources such as textbooks, teaching materials, experimental equipments, and so on, are effective when teaching science.

The professional development issues point out various ways in which, in teacher´s opinions, science teaching is supported such as pre and in-service training programs, mastery of content, collaborative teacher´s assessment.

Referring to first issue teachers believe that educational factors such as textbook, assessment, subsunsors are mainly influential in science education (63.81% - 77.20%), as it is shown in the following tables.

Category: Didactics - Subcategory: textbooks

Option	Σ	% Σ
None	12	2,51
Very negatively	1	0,21
Negatively	8	1,67
Without influence	12	2,51
Positively	369	77,20
Very positively	76	15,90

Category: Didactics - Subcategory: Form of assessment tests

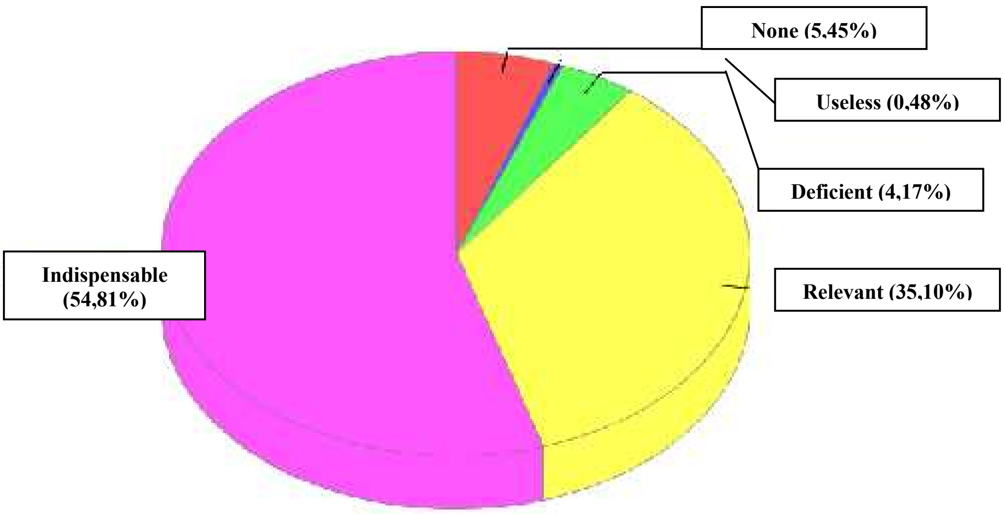
Option	Σ	% Σ
None	53	11,09
Very negatively	3	0,63
Negatively	20	4,18
Without influence	50	10,46
Positively	309	64,64
Very positively	43	9,00

Category: Didactics - Subcategory: Subsunsors

Option	Σ	% Σ
None	46	9,62
Very negatively	1	0,21
Negatively	17	3,56
Without influence	23	4,81
Positively	305	63,81
Very positively	86	17,99

As factors related to their professionalism, teachers rate the usefulness of their training contributions (60.88%) and rate very positively the domain of disciplinary content (98.28%).

On the other hand, teachers give importance (86.82%) to the factor *"interaction with colleagues"* when teaching science. The following chart shows:



With regard to teachers´ opinion on actions to improve science education (Question 8), they strongly recognize the importance of increasing physical and financial resources (78.03%) and construct special laboratories (69.04%). Thirdly, they ask for secure connections to Internet (55.65%).

Regarding policies to reorient the teaching of science they believe in a percentage lower than 50% in the importance of changing training processes (initial and continuous), reorganizing the work of teaching and engaging extra-school staff (assistants, bilingual teachers) in educational practice. In terms of public policy a 63.39% think that it should be changed the criteria for teacher selection.

Category: Professional - Subcategory: Exchange with colleagues on successful or not experiences in the classroom

Option	Σ	% Σ
None	21	4,39
Useless	3	0,63
Deficient	22	4,60
Relevant	170	35,56
Indispensable	262	54,81

Category: Professional - Subcategory: Link teaching practice/educational research

Option	Σ	% Σ
None	39	8,16
Useless	7	1,46
Deficient	11	2,30
Relevant	195	40,79
Indispensable	226	47,28

Category: Didactics - Subcategory: Devolpmentent of new didactical materials

Option	Σ	% Σ
None	23	4,81
Useless	7	1,46
Deficient	8	1,67
Relevant	150	31,38
Indispensable	290	60,67

Among the professional factors teachers highlight the importance of sharing with colleagues and of linking their practice with the results of educational research (88.07%).

The study also reveals the need of new materials developing, recognized by 92.05%, and achieving mastery of disciplinary content (98.28%), giving support to a better science teaching.

CONCLUSIONS

478 elementary school teachers answered a 14-items questionnaire. Questions arise opinions and conceptions about the basis of science teaching: the influence of didactical approaches and of professional background as well as cultural issues, such as socio-cultural and interpersonal relations factors which improve or impede a better science teaching. This survey has TRACES research project as a framework.

Question 6 and 8 are selected because they refer to the inner classroom practice of teachers by considering the practice itself or the pre-service teacher´s training or the in-service teacher training, the interaction with colleagues, as well as the importance given to the didactical devices.

It is stressed the importance of ensuring teaching science through content mastery and teaching strategies management. It is remarked the importance of providing didactical materials and financial resources, laboratories, internet connections when teaching sciences. Teachers also give importance to guidelines and evaluation criteria and presence of learning subsunsors. As professionals they recognize the convenience of working with colleagues and the contribution of researchers to their professional practice.

These results, from a didactical or a professional point of view, allow the design of successive research phases looking for narrowing the research-practice gap, the principal TRACES objective.

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INTEGRATED TEACHING OF SCIENCE AND TECHNOLOGY IN FRANCE: AN EXAMPLE OF A COOPERATIVE TEACHING.

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Abstract: In France, since 2006, an Integrated Teaching of Science and Technology (ITST) has been set up as innovation in middle school. First and foremost its goal is to bring a new unit of teaching in which Science and Technology are not poles apart from different disciplines. The implementation of ITST by teachers usually specialized in one discipline (biology, physics or technology) needs to develop news teaching ways. Within a theorical framework Didactic of Curriculum and using a methodology based on Content Pedagogical Knowledge (PCK), are mobilized by teachers to implement ITST. This data was collected from two sources : official instructions and video recordings teachers' meeting to prepare lessons or teaching in classroom. The results show the emergence of a new curriculum, and a new approach of teaching but without necessarily devoting oneself to one skill widening from initial discipline teaching.

Keywords : curriculum- cooperation – specialist – integrated – school discipline

1. INTRODUCTION

Integrated Teaching Science and Technology (ITST) is promoted to prospect for European and International Education Program. Instance of this, Quebec in 2007 gave up the former scheme in distinct disciplines, so that integrated teaching could be kept on. Australia, Taiwan, Greece have also experimented an integrated teaching. In France, the French Ministry of Education and the National Academy of sciences and technology has been supported ITST as an innovation since 2006. To implement ITST, Inquiry-based Science Education (IBSE) is recommended and two main topics are concerned that is : Energy and Material. Actually, fifty middle schools have taken part in ITST innovation, including pupils for grade 6 (age 12).
In France, ITST contrast with the traditional scientific teaching. Usually biology, physics and technology are three main disciplines taught in secondary school. As regards ITST, a teacher specialized in one of these disciplines become a teacher of Science and Technology (Fig 1).
ITST is a new teaching and a new professional experience for teachers. To keep up with it, the latter must share their conceptions about integrated teaching and build on a new way of teaching. Drake (2007) explains how teachers must overcome their resistance to elaborate integrated approaches and strategies. They need to cross different approaches (multidisciplinary, interdisciplinary, or transdisciplinary) and different teaching strategies to include thematic subjects, learning projects, IBSE practice in integrated curriculum.

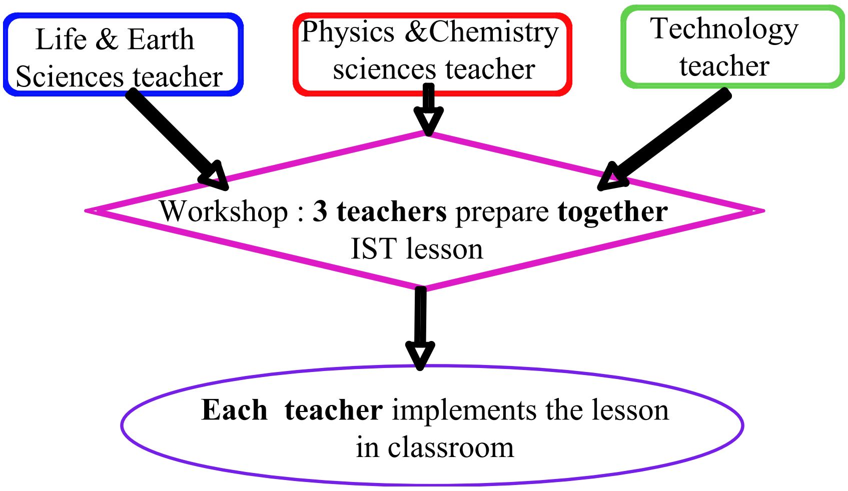

Fig 1. Organization of ITST

This new teaching device have a significant impact on teaching practice and relationship between teachers. For example, to get ready to work out a lesson, three specialized teachers, each one in one discipline, meet once a week to carry out choices and make decision. But, implementation of ISTS is conducted by each teacher in classroom of S& T.

2. RATIONALE

Firstly to study the collective construct and the individual practice, we are likely to use the framework proposed by Martinand (2003) going through curricular steps. By curriculum, we are acknowledged upon official instructions, not to mention the references that guide teachers' choices. Our analysis is based on four steps (Fig 2).

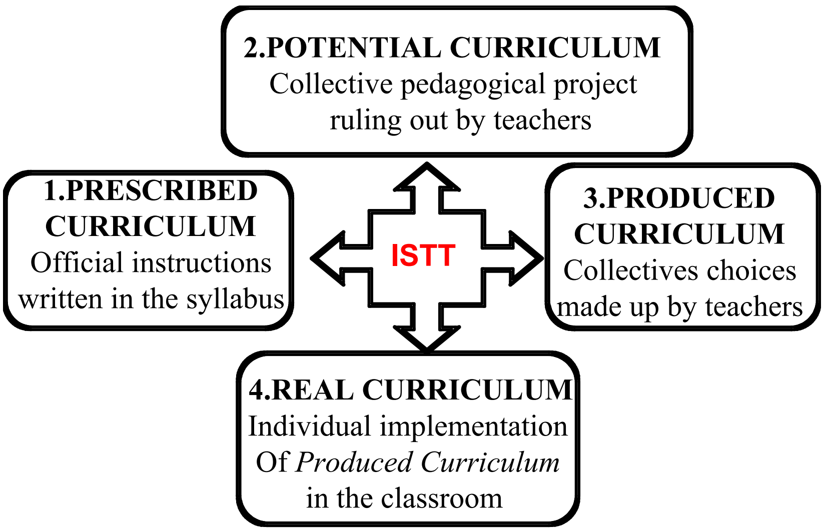

Fig 2. Stages of curriculum development

- *Prescribed curriculum*, i.e. official scientific or technological content for each discipline and also pedagogical activities for pupils;

- *Potential curriculum* is characterized by different teachers's interpretations of the prescribed curriculum;
- *Produced curriculum* is a transcription of the teachers's choices within different interpretations from the prescribed curriculum ;
- *Real curriculum* corresponds to what each teacher really implements in his classroom.
As for each curriculum, the purpose is to identify which knowledge is mobilized by teachers and what difficulties they encounter in implementing ITST.
Our hypothesis is implementation of ITST requires for specialized teachers (biology, physics or technology) to go well beyond the field of their own disciplinary teaching and eventually acquire new professional knowledge. How does a specialized teacher became involved in ITST and jointly worked out the ISTT implement ?

More precisely, we question :
- The relationship between specialized teachers to implement ITST;
- The stand of the teacher either a teacher of « S&T » or a specialized teacher who will bring out his expertise in ITST;
-The role of the IBSE to unify S&T;
- The meaning of the "I" of ITST does it mean integration of disicpline, interdisciplinary, unlikeness of school disicpline ?

Thus ISTT implementation requires :
- firstly to cross school disciplines
- secondly to acquire a new professional expertise connected with a new way of teaching.

The goal is to determine what pedagogical knowledge are summoned up by 3 teachers to develop and implement ISTT.

3. METHOD

We hold on a case study two teams (from two different middle schools) of three teachers, each one specialized in biology, physics or technology.

Data collection and corpus

Data collection is provided
- for the *prescribed curriculum,* content of official instructions in ITST and also supplied by two curricula topics namely "Energy" an "Material";
- for the *potential curriculum,* with exchanges and negotiations talk between the three teachers to get ready the lessons in ITST, from transcribed video recordings (10 hours);
- for the *produced curriculum*, with the notebook where team-teachers write down the choices of progression, demonstrations, explanations to help the learners.
- for *the real curriculum*, with the interventions of each of the three teachers in ITST classroom, from transcribed video recordings (10 hours).

Analysis of the corpus

To answer our research questions, we try to determine what knowledge is mobilized by teachers according to four curricula above. Analysis of the corpus has been based on *Pedagogical Content of Knowledge* (Shulman, 1987) :
- *Subject Matter Knowledge (SMK)* or content knowledge in academic disciplines,

- *Pedagogical Knowledge (PCK)* or teaching knowledge to transform the content ITST into a powerful pedagogic (illustrations, demonstrations, explanations...),
- *Knowledge of learners (KL)* or misconceptions, taken into account of the learning difficulties to the pupils,
- *Curricula Knowledge (CK)* or content knowledge of the school curricula and the pedagogical equipment available (laboratory material, software...) to implement ITST.

For example during the concertation meeting to elaborate the *potential curriculum*, teachers refere to Energy concept. At first, starting from their own discipline, each of them gives a specific definition, and so, they mobilize SMK from academic disicpline. After that, the discussion is concerned with what kinf of examples are likely to be choosen to illustrate energy. Teachers of technology and physics propose electric energy while the teacher of biology will propose muscular energy. In this case, each teacher mobilizes “disciplinary PCK”. But sometimes, team-teachers try to combine transversal examples of energy as a common transformation process from a source (sunlight for electric energy or nutriments for muscular activity). In this case, they mobilize a shape of “integrated PCK”.

4. RESULTS

The analysis highlights different results.

- As for the *prescribed curriculum*: Content Knowledge of biology and physics and technology are patchwork-stuck. Moreover, a tension between disciplinary curricula and the interdisciplinary topics in ITST results in.
Out of 34 items in the Teacher’s Guide book « Matter and Materials » the graph (Fig 3) shows the distribution between school disciplines. We note down that traditional school disciplines are a minority compared to cross-disciplines.

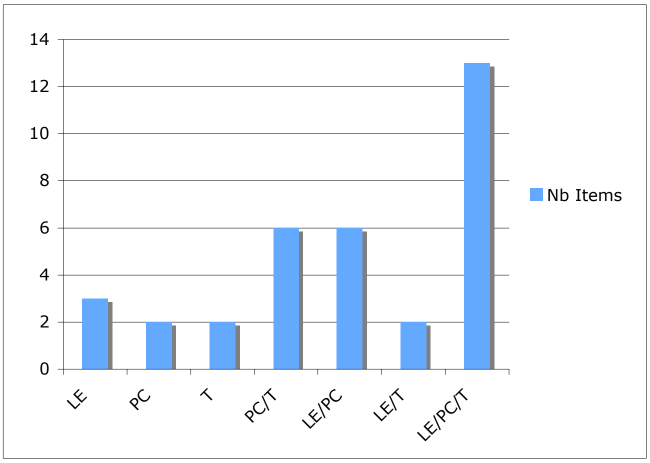

Fig 3 : Distribution items according to school disciplines in the guide book
(LE : Life and Earth science, PC : Physic and Chemistry science, T : Technology)

Each school disciplines items mobilize MSK (e.g concepts : matter, energy, cell, technical object …) and then, when one crosses disciplines items, PK is mobilized.

- As for the *potential curriculum*: collaboration and cooperation between teachers is vividly expected about content knowledge in academic disciplines, about teaching Knowledge to clear up the pedagogical goals for ITST and decide the many choices to get through with it.

During the discussion between the three teachers, four types of knowledge are mobilized :
- MSK are summoned to try a common definition of energy
- KL to anticipate the difficulties to be overcome and pupils'skills to undertake something…
- PK to plan the lesson.
- CK about laboratory equipment useful for the lesson

The graph (Fig 4) shows that a great deal of time is spent upon the discussing of laboratory equipment and planning lesson (e.g some teachers do not know how to use the laboratory materials : a miscrocope, a drill, a software, or else and so, they need to be guided with a specialist teacher's eye).

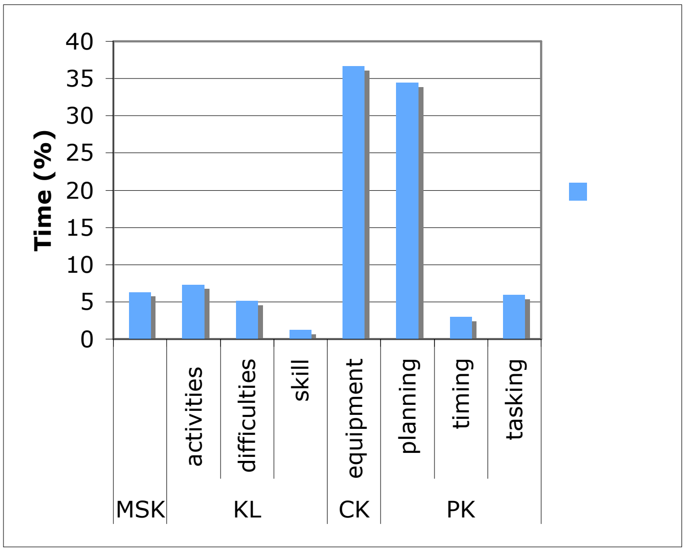

Fig 4. Units of discussion and time spent (%) during a working meeting (92 min)

- As for the *produced curriculum*: plan, organization and activity tasks for learners (Fig 5).

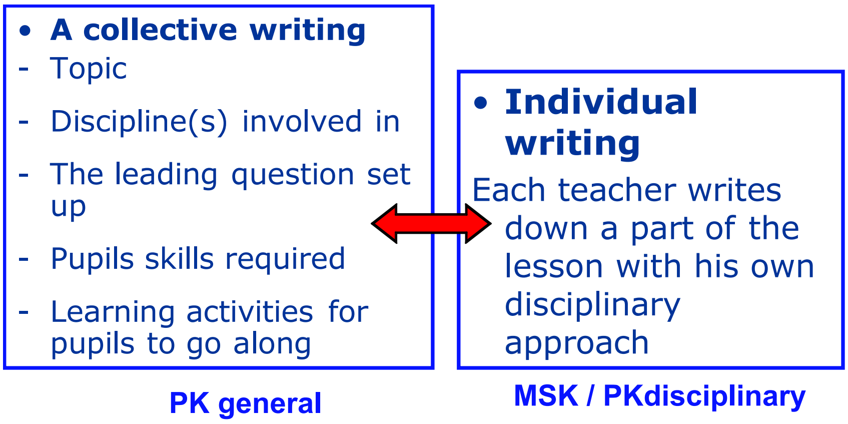

Fig 5. Organization of the working paper for the lesson

On the one hand, PK about the plan of a lesson are summoned up by a teacher team to produce a working paper, in 5 points come to focus : topic/ discipline involved in /, the leading question set up/, pupils'skills required and learning activities for pupils .

On the other hand, each teacher writes down a part of the lesson with his own disciplinary approach (MSK or PK disciplinary).

Concerning the tasks appointed to the learners about specific concept (i.e construct a breeding cycle), team teacher delegates the drafti of the learning task to the teacher who is recognized by all, as a specialist (in this case the teacher of Biology is called in). That is, each teacher bring its expert testimony in a discipline to an integrated teaching. So to say, each team of teachers form each school produces a "local" curriculum, that is to say, they don't exactly choose the same pedagogical goals or activities tasks for learners.

- As for the *real curriculum*, each teacher introduces him(her)self in classroom of « S&T » as a teacher of S&T and not as a teacher in biology, physic nor technology Nevertheless, teachers don't always master the MSK the learners are due to be taught. Teachers can't figure out the difficulties or the misconceptions of learners and sometimes are unable to answer their questions. This deficiency is compensated with a friendly talk between teachers. In this case, the teacher explicitly tells the pupils off that he must seek out for a specialist teacher's help to fill in the gap of the expertise knowledge of the disciplines. He or she mobilize cooperation knowledge.
To describe IBSE, each teacher does reference to the professional practices from academic discipline. Thus, two ways of thinking IBSE arouse either experimental method with scientific practices for teachers in biology and physics, or design method with manufacturing practices for teachers in technology.

5. CONCLUSION

In comparison with other studies, in particular the Australian study led by Wallace & al (2007) we have also noted a disparity between Integrated Curriculum prescribed and the real practice in ITST, because Integrated Curriculum practice doesn't exist. ITST is a new way of teaching without professional memory assess or pedagogical tradition. If group work is recommended, the organization is very disparate according to the schools.

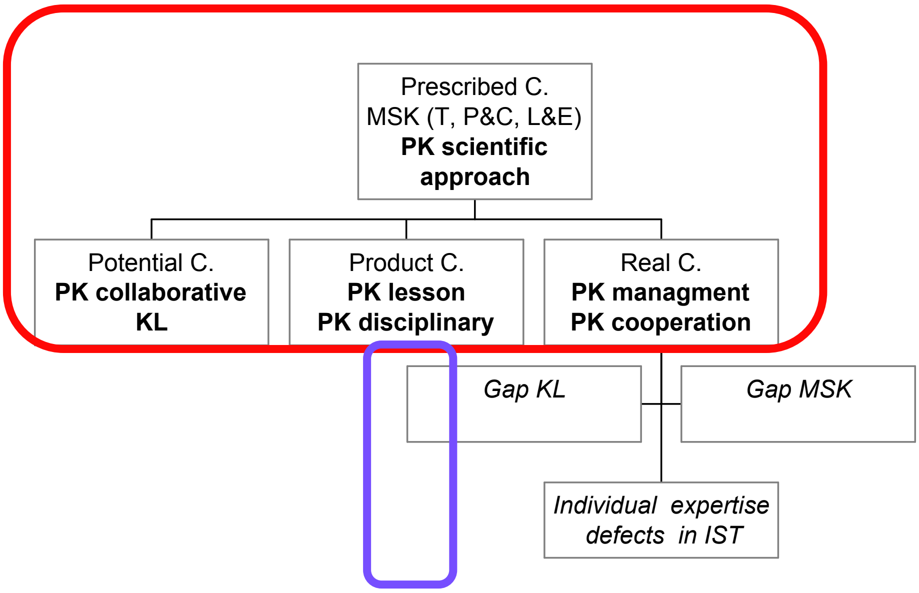

Fig 6. Knowledge mobilized in the developement of local curriculum
(Red frame : collaboration and cooperation between the 3 teachers, blue frame : limit of professional enlargement in S&T for each specialized teacher)

In conclusion, each curriculum is characterized by different knowledge and it is difficult for each specialist teacher to go out of the speciality field.
The implementation of ITST in classroom, from a local curriculum collectively produced needs worthwhile collaboration and cooperation between specialist teachers. Still, it appears that there is no professional widening from the speciality.
Anyhow, the collaboration seems to open prospects with new disicplinary interactions. Noting collaboration between teachers from different disciplines constitute here a real newness in the professional development. Meanwhile, there is a paradox. At the moment, ITST innovation in France is more a juxtaposition of disciplines rather than a real integration. But, it also appears that the meaning of "integration" in ITST must be understood like the disappearance of the school disciplines in a new school discipline « S&T ». At all events, this new integrated teaching seems to raise a new speciality teaching claim for an ITST specific curriculum.

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SEMIOTIC MEDIATION AND DIDACTICAL CYCLE AS METHODOLOGICAL REFERENCE FOR PRIMARY SCHOL TEACHERS

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Abstract: The theoretical framework of semiotic mediation, after a Vygotskian approach within activity theory, fruitfully introduced for mathematics education, has been transposed and adapted to laboratory science education activities. Aim of this paper is to show how this framework can be used as a methodological reference for teachers to mediate scientific meanings. An example addressed to teachers of application to laboratory activities with a jet car toy is proposed.

Keywords: Semiotic mediation, Force Dynamic Gestalts, Energy, Didactical cycle, Primary school science education

DEFINITION OF THE PROBLEM

Primary school teachers have difficulties in teaching sciences and in particular in driving laboratory activities, addressed to meaning construction and modeling, to achieve a lasting effect of science education. Science laboratory activities risk to be reduced to a set of trivial practices, or mere manipulation, or twiddling, to be executed by students, without the suitable and precise teacher's guidance, while, according to the Vygotskian perspective of *obucenie* (Mecacci, 1990), the teacher's active role is fundamental. In literature or in textbooks, a wide variety of educational school courses is documented, while effective methods on teaching /learning processes are not so widely available. In this contribution, after a synthetic presentation of a proposal of a methodological framework, an example of semiotic approach to introduce students' to energy meaning construction will be presented and discussed.

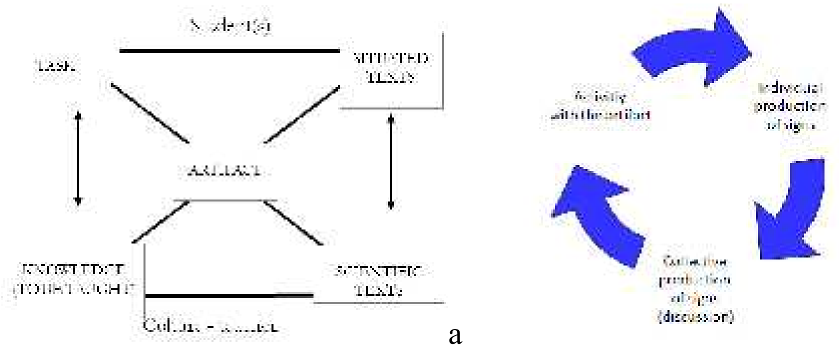
PLACE IN THE LITERATURE

In mathematics laboratory education exists a well defined and consolidated framework of semiotic mediation (Bartolini & Mariotti, 2008) to guide and foster methodological and educational competencies in teachers. This fits Vygotskian tradition that considers learning a mediated relation between individuals and knowledge. Artifacts and instruments are key terms of Rabardel's theoretical construct that defines an instrument as "a mixed entity made up of both artifact-type components and schematic components that we call *utilization schemes*. This mixed entity is born of both the subject and the object. It is this entity which constitutes the instrument which has a functional value for the subject" (Rabardel & Samurçay, 2001). However Rabardel's approach is not enough to be used in teaching/learning processes in which

Vygotsky's analysis of technical (artifacts) and psychological (sign)[1] tools and Hasan's (2002) investigation of complex semantic relations of mediation processes are necessary. In the learning process, a child needs the help of the teacher to cross the Vygotskian zone of proximal development and to internalize new knowledge.

SEMIOTIC MEDIATION AND DIDACTICAL CYCLE FOR SCIENCE

The key terms of Bartolini & Mariotti's framework can be reinterpreted to suite the specific case of science. Fig. 1a reports the sketch of the elements and the links of the theoretical framework of semiotic mediation adapted for science.



a b

Fig. 1. Elements and links of the (a) theoretical framework of semiotic mediation and (b) the didactical cycle

At the centre of the laboratory work there is an *artifact*. The artifact, may be any scientific "instrument" available in scientific laboratories (easily assimilated to mathematics artifacts and to Rabardel's genèse instrumentale) or the reproduction in the laboratory of a piece of reality, according to the analysis of Knorr-Cetina (1999), with the aim of simplifying and focusing particular aspects. The artifact embodies meanings that students have to discover and internalize, and this is stimulated by the *task*. The task, a question or a problem posed by the teacher, reflects the fundamental steps of a scientific research. The tasks may refer, for example, to the description of the artifact itself and of the function of its parts, or to the prediction of its behavior under certain conditions, the solution of a problematic situation or the way to achieve a certain result, the description of a process or of a phenomenon involving the artifact, its interpretation, the identification of relevant invariables as well as their relations. The teaching-learning process starts with the emergence of students' personal meanings in relation to the use of the *artefact* The students, stimulated by the task, construct personal meanings through *utilization schemes* of the artifact, i.e. from simple manipulation and exploration of the artifact, to well designed experiments with choice of the parameters and of the quantities to be varied and measured. The teacher's role here is again fundamental and well defined. By all these activities children produce some specific personal *signs* (written or oral words, gestures, drawings,...) that the teacher may recognize and interpret as "pivot" signs to be made evolving. "pivot" signs may be used by the teacher to create a link between the plane of concrete experience and the plane of meanings, for the evolution towards *scientific text* and the processes of meaning construction. Their evolution has to be fostered by the teacher through specific social activities. In summary, the process of semiotic mediation consists in the evolution process that has its first step in the emergence of personal meanings related to the accomplishment of a task and develops in the collective construction of shared signs related to both

[1] The sign acts as an instrument of psychological activity in a manner analogous to the role of a tool in practical activity

the use of the *artifact* and the science to be learnt. This evolution is promoted through an iterate cycle (Fig. 1b) that includes (i) activity with the artifact, (ii) individual production of signs, and (iii) collective discussion, pointing at the shift between the *situated texts* produced by the children (Fig. 1a) to forms of *scientific texts* (suitable to students' age) that are decontextualized from the specific situation and, at the same time, able to evoke the concrete experience. Each of these activities contributes differently but complementarily to develop the complex process of semiotic mediation (Bartolini Bussi & Mariotti, 2008). *Activities with the artifact* constitute the start of the cycle. They are based on tasks, as are designed with the aim of promoting the emergence of signs related to artifact use. In some activities students are involved *individually*. For instance, students might be asked in classroom or as homework to write individual reports on the previous activity with the artifact, reflecting on their own experience and raising possible doubts or questions, to find analogous situations to the studied one. Written productions can become objects of discussion in the following *collective classroom discussion*. This third activity plays an essential part in the teaching-learning process and constitute the core of the semiotic process, on which teaching-learning is based. The whole class may be engaged: for instance, after a laboratory activity, the various individual or small group descriptions and interpretations (students' written texts or other texts) may be analysed, commented and discussed collectively. The main objective of teacher's action in such a discussion is that of fostering the move towards science meanings, taking into account individual contributions and exploiting the semiotic potential coming from the artifact use (for the elaboration of the concept of Mathematical Discussion, see Bartolini Bussi, 1998a, 1998b).

In the different steps of the methodological framework we have here illustrated the teacher's role is different and crucial. It ranges from the choice of suitable tasks, which exploit the semiotic potential of an *artifact*; to the professional recourse to suitable interaction strategies during the tricky step of classroom discussion. The study of the teacher's role is in progress in pilot experimentations with teachers-researchers and in the diffusion of classroom activities with *artifacts* to the broad education system.

A POSSIBLE TEACHER TRAINING PATH ABOUT ENERGY

In order to apply this methodology, teachers need first to be trained, putting themselves in the same situations (i.e. using the same artifact, answering to similar tasks, producing and discussing pivot signs they expect from students) they could offer to their students, thus to experience possible difficulties and needs of children and to focus science knowledge in relation to children experience urged by the artifact use as *instrument.* In the following, we outline an example of contents of an application of the semiotic mediation framework addressed to teachers with children of the 4th and 5th grades. We will refer to the elements shown in Fig. 1.

The piece of knowledge to be taught. The concept of energy is very hard to be understood by young students. However some basic concepts can be introduced very early to prepare the scientific meaning construction in a vertical curriculum perspective, i.e. the identification and differentiation, teacher guided, of the Force-Dynamic Gestalts (FDG) (Fuchs, 2007). They are the schemas that the mind uses to make sense of experience, by metaphorically projecting them onto concrete phenomena. Various phenomena, such as those involving the behavior of fluids, electricity, heat, motion, and chemicals, treated separately by different fields of science, can be understood in terms of analogous basic and simple structures already present in children's minds (Fuchs & al., 2011).

Metaphoric actors of natural processes are fluid-like quantities (extensive quantities), with associated intensities (generalized potentials or intensive quantities) which differences (potential differences) drive fluxes. The power of a process in an interaction is determined by its quantity and the connected potential difference: a certain increase of potential of a certain quantity (effect of the interaction) occurs at the expense of a certain decrease of potential of another certain quantity (cause in the interaction). The concept of energy then arises from the identification of the "proportion" between two processes taking part in an interaction.

The artifact. We consider a jet-car toy (Fig. 2).

Fig. 2: The jet-car artifact.

Other artifacts can be, for example, a putt-putt boat, a windmill, a dynamo torch, or, with reference to natural sciences, a tree, an ecosystem, the blood circulation, the water cycle, chemical reactions etc.

The task. The tasks invites observing and investigating how a device (a toy) functions; the relationships between its parts; how the problematic situations posed by the task may be solved; the prediction of the behavior of the apparatus under certain initial conditions; the interpretation of the observations (Mariani & al., 2011). With reference to the jet-car, the tasks can be grouped as: (A) exploration of the toy as an artifact (Describe the jet-car. Describe and draw by which parts is it composed); (B) exploration of the experimental apparatus as a tool (How could you use it? How could you make the car go faster? Or go further?); (C) use of the toy with utilization schemes (After the experiments: What did you do with the jet-car? What did the car do? How do you explain your observation? Perform several experiments with the inflated balloon to move the toy car by changing the air in the balloon and the mass of the car. Make changes one at a time); (D) search for relationships, detailed analysis of the toy (balloon inflated and exhaust hole kept closed: What quality has the air in the balloon? What does the air "feel"? What quality has the jet-car?; exhaust hole open: What quality has the air while it is coming out of the hole? What does it "feel"? What quality has the air after it is come out of the hole? What does it "feel"? What quality has the jet-car while the air is coming out from the hole? What does it "feel"? What quality has the jet-car after all the air has come out of the hole? What does it "feel"?). Each task generates a didactical cycle.

The evolution of situated texts towards scientific texts. In a real case, for every task, children produce sentences, words, expressions, drawings, sounds, gestures that the teacher may recognize as "pivot" signs. For example, during a collective discussion, pivot signs could be: "air is trapped", "a wind exits the hole", "air mixes with outer air", "the car moves forwards while the air is blown out", "the car gradually stops", "more air-more speed", "all is resting",… Teachers, once invited to hypnotize possible students' situated texts, have to be trained to conduct collective discussions for gradual construction of scientific meanings starting from the pivot-signs. The steps in the case of energy could be: i) description of the process as a whole using common language; ii) refinement of the language used, stressing quantities that play a role; iii) description of the process in terms of fluid-like quantities, associated differences of potential and elementary concepts (current, resistance, capacitance, etc.); iv) interpretation in terms of cause-effect (so far the word "energy" is still not used); v) introduction of energy as proportion between causes and effects.

A possible scientific text that teachers should make is the following. *When the balloon deflates, the car accelerates, reaches maximum speed and gradually goes to rest. The air expelled backward pushes the car forward. The car moves but, at the same time, loses motion. After the balloon is completely deflated, the car looses all its remaining motion and stops.* A more formal text could be the following. *The air expands due to the pressure difference and exits at high speed from the car nozzle. Thus momentum is transferred to the car proceeding in the opposite direction. The car accumulates momentum and, at the same time, transfers part of it to the earth as a consequence of the velocity difference. When all air has been expelled, the car momentum gradually flows to the earth until the velocity difference becomes zero. The air pressure causes the transfer of momentum from the air to the car, air interacts with the atmosphere and car interacts with earth causing production of heat. The energy contained in the compressed air is transferred to momentum (a greater fraction to the air than to the car) and from momentum to heat.*

CONCLUSIONS

We have proposed a methodological framework of semiotic mediation and the didactical cycle worth introducing to teachers as reference for scientific meanings construction in laboratory activities.

The various elements and links have been discussed and exemplified for the case of energy meaning construction. This work shows the feasibility to anchor scientific meaning construction to children's reasoning, starting from the image schemas of the FDG, suggesting a methodology that makes the teacher confident in the use of natural language.

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SCIENCE TEACHERS' NARRATIVES ON MOTIVATION AND COMMITMENT – A STORY ABOUT RECRUITMENT AND RETENTION

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Abstract: Evidence of problems in science teacher recruitment and retention are often provided in statistical overviews. The individual science teacher's recruitment is based on subjective motivation, and retention is based on continued motivation and commitment to science teaching. Narratives constitute a way to learn more about the individual teacher's motivation and commitment. Narratives were collected from 10 Danish science teachers, teaching 4th to 10th year science subjects. This paper focuses on two of these. Their motivation for choosing and staying in science teaching differs. Tina was recruited into science teaching through inspiring teachers in primary and high school and a desire to do good for others; this motivated her to choose teacher education and biology as a major teaching subject. After 9 years of teaching she is retained in teaching by her commitment to treating the children as whole human beings. Jane was recruited into science teaching by an interest in outdoor life; this motivated her to choose teacher education and biology as a major teaching subject. After 32 years of teaching she is retained in teaching by a commitment to developing outdoor science education. Teachers' narratives give individual stories of science teacher student recruitment, as well as retention for in-service science teachers. It is the individual choices of coming and active science teachers that sum up in the recruitment and retention statistics.

Keywords: Narratives, Commitment, Motivation, Retention, Recruitment

BACKGROUND

Teacher recruitment and retention has been an area of much interest (e.g. Cooper & Alvarado, 2006; Guarino, Santibanez & Daley 2006; Nordisk Ministerråd, 2009; Hare & Heap, 2001). In many countries there are reports on problems of imminent shortages of science teachers (Danmarks Lærerforening, 2007; National Comprehensive Center for Teacher Quality, 2007). The above studies provide mostly statistical overviews of the problem, which show the magnitude of the present problem and the expected development of the future problem. In Denmark e.g. only 57% of the lower secondary teachers teaching biology have completed subject matter education in biology and only 18% of the teachers teaching primary science have completed subject matter training in primary science (Danmarks Lærerforening, 2007). Such statistics gives an idea of the scope of the problem, but do not provide any insight in the individual teacher's reasons for and approach to teaching science.

Many studies focus on the first difficult years of teachers' professional careers studying different forms of mentor programmes and their effect on the retention of newly started teachers (Ingersoll & Smith, 2004; Hanuscin & Lee, 2008 and Luft, Wong and Semken, 2011). Luft, Wong and Semken (2011) call for a more comprehensive and strategic orientation towards the recruitment of secondary science teachers, and they recommend more focus on the induction period and science teachers' start of their professional career. Such studies on induction programmes are beneficial for expanding our understanding on relations

between recruitment into and the start of science teacher careers, but do not provide insight into the long-term retention over an entire science teacher career.
Recruitment and retention studies on teachers use different approaches such as questionnaires among first year teacher students in order to understand the social and cultural background for recruitment to teacher education (Stage Petersen, 2010); or narrative inquiry in order to understand details in teachers' life and work contexts (Day et al, 2007). This paper will present experienced science teachers' narratives on their experiences in the teaching profession. The research interest is focused on understanding long-term retention through questions on the reasons why the individual teacher chose a teaching career and why the individual teacher chose science as a teaching subject.

RATIONALE

Science teachers' narratives on their choice of education and on their practice is a way to learn more about the recruitment into science teaching as a profession, and the retention in it over an entire career. Persson (2009) interviews teacher students in Sweden and find their recruitment being motivated by experiences prior to starting on teacher education. Using their narratives he is able to describe their subjective motivation for choosing teacher education and to partly understand the underlying social recruitment patterns. He distinguishes between 4 types of motivation: walk in the footsteps of a master, work with your hobby, invest in teacher education, and avoid beers and mopeds.
Day et al (2007) has made an extensive study of teachers' lives, work and effectiveness in the UK using both qualitative and quantitative methods. They distinguish (ibid, p. 213) between two types of retention: a physical continuation, and a maintained commitment and motivation. They base the latter retention type on interview-generated teacher stories and conclude that commitment has major implications for teacher effectiveness.
This paper will discuss these types of motivation and retention using narratives on initial motivation and the commitment of two science teachers in Denmark. The science teacher narratives on motivation and commitment illustrate aspects of recruitment into and retention in science teaching.

METHODS

The narratives were collected in the autumn of 2010 and the spring of 2011 during an ongoing Ph. D. research project in Denmark. The project uses primary and lower secondary school science teachers' life histories to investigate their motivation for and commitment to science teaching. The research design is inspired by Norrie and Goodson (2011) using life-history interviews, observation of the teachers teaching, and collection of materials produced by the teachers such as pupil assignment sheets, subject-oriented letters to parents, and written in-service training assignments, etc. The narratives will be presented in a condensed form in this paper; all translation is done by the author.
The teachers were chosen so that they have several years of teaching experience; such teachers are past the first troublesome years in a teacher career. Their long experience in science teaching makes it possible for them to tell about the long-term retention in focus in this research project.

RESULTS

The 10 teacher-narrators represent 6 schools placed in different socio-economic settings. The teachers have all completed the 4-year teacher education in Denmark; they have attended 3 different colleges of education for their pre-service qualification. They are all qualified for teaching in Danish public education from 1st to 10th year. Table 1 presents background data of the teacher-narrators' life and education prior to their teaching practice. The two oldest teachers were recruited directly from high school, whereas the others all had other work or educational experience prior to starting their teacher education. This pattern of delayed recruitment including changes from other careers into teaching has become more frequent during the last decades in Denmark (Stage Petersen, 2010).

Teacher alias	Gender	Year of Birth	High school or similar finished in	Other training or employment prior to teacher training	Start of teacher education	Graduation as teacher
Jane	♀	1954	1974		1974	1978
Erik	♂	1957	1977		1977	1981
Lars	♂	1956	1976	Clerk	1982	1986
Diana	♀	1970	1990	Shop assistent	1992	1996
Linda	♀	1956	1994	China Painter, shop owner	1994	1998
Simon	♂	1971	1990	Laboratory worker	1997	2001
Tina	♀	1975	1995	Kitchen assistent, Videoshop manager	1997	2001
Frank	♂	1973	1997	Farmer, Nursery assistent	1999	2004
Karen	♀	1966	1985	Industrial worker	2001	2005
Ruth	♀	1972	1992	Nursery assistent, Occupational therapist	2002	2009

Table 1: Background data of the 10 teacher-narrators.

The two teachers in focus, Jane and Tina, were chosen since they represent different commitment to and motivation for science teaching. Jane teaches 4th to 6th year at a school with 400 all Danish-speaking pupils in a small town of 8,000 inhabitants. She is married to a farmer and lives on a farm; she was born in a town 30 km from her present home. Tina teaches 7th to 10th year at a school in a town of 25,000 inhabitants. The school has 800 pupils of whom 200 are bilingual. She is married to a mechanic and lives in the town where she was born and now teaches. Jane and Tina were both trained at a teacher college (approx. 125 teacher students at each year) close to where Jane now lives. In pre-service education Jane was educated in Biology and Sports as her major teaching subjects, whereas Tina was educated in Biology and Danish.

Motivation for choosing science teaching

The majority of the 10 teacher-narrators tell that they chose teaching because they care for children and other people. Tina is in accordance with this majority in describing her motivation for choosing teacher education.

> Tina: From 1st to 6th year I had a male class teacher, he was so nice, a very good newly educated male teacher. What he gave us I also wanted to give someone someday.

Jane has another motivation for choosing teacher education; she considered university studies in biology or a career as ballet dancer.

Jane: After high school I wanted to be either a ballet dancer or game biologist, in teacher education I could get a bit of both. The teacher college wasn't that far away, I had a sick mother at that time.

All the teacher-narrators have positive experiences with science education, nature preservation or outdoor life prior to entering teacher training. Jane and Tina illustrate different types of experience that have motivated them to choose biology as a major teaching subject.

Jane: I loved helping out at my uncle's farm. Our holidays were fishing trips. It was obvious for me to choose biology as a subject for teaching, biology has been THE line for me.

Tina: I had the nerdiest nerd in biology in high school, but he was very funny, he had a good approach to biology ... very good at making images in our heads.

Jane's narratives are in accordance with Persson's 'work with my hobby' type of motivation, and she is still very active hunting and caring for game in her spare time. Tina's narratives are an example of Persson's 'walk in the footsteps of a master', she tells of no science or nature related hobbies. The narratives presented are more focused on everyday teaching and less oriented towards conditions of employment than discussed in the literature available in general (e.g. Hare & Heap, 2001; National Comprehensive Center for Teacher Quality, 2007)

Commitment to science teaching

The teacher-narrators have very different reasons for still being committed to science teaching. Jane is committed to improving the possibilities for outdoor oriented science teaching as she has raised money to restore a pond near her school, so that it can be used in biology teaching.

Jane: This pond is a little diamond, but it needs restoration so as not to become choked. You should be able to fish for water insects in it.

Tina has taken on the task of being a coach to pupils with emotional problems and in her biology teaching she puts emphasis on sex and health education, which is part of the biology curriculum in lower secondary school in Denmark.

Tina: I want to have a positive influence on the young people. My attitude is that it is half subject matter and half social worker, because we are to turn whole humans out in the end. I'm developing a curriculum for the sex education at my school.

Tina's commitment is the relation to the pupils and their well-being both physically and emotionally as whole human beings. Jane and Tina both show continued commitment and motivation to developing science teaching at their schools, which is in accordance with the way Day et al. (2007) describe maintained commitment and motivation. The narratives give more positive and affective reasons for staying in the science teaching profession than those provided in the literature in general (e.g. Guarino et al, 2006; Hare & Heap, 2001).

CONCLUSIONS AND IMPLICATIONS

The teacher-narrators carry their initial motivation for choosing teaching into their science teaching practice. Tina was recruited into science teaching through inspiring teachers in primary and high school and a desire to do good for others; this motivated her to choose teacher education and biology as a major teaching subject. After 9 years of teaching she is retained in teaching by her commitment to treating children as whole human beings. Jane was recruited into science teaching through an interest in outdoor life; this motivated her to choose teacher education and biology as a major teaching subject. After 32 years of teaching she is retained in teaching by a commitment to developing outdoor science education. Despite their commitment to parts of the science curriculum, Jane and Tina teach the entire curriculum of their science subjects with competence.

Teacher education is no longer a frequent first choice of education, which brings different types of experiences of relevance to science into teacher education (table 1). Recruitment to science teacher education could benefit from engaging in initial motivations and prior experiences in order to challenge and develop student teachers' interests and perspectives beyond their immediate motivation for science teaching.

Retention in science teaching can be accomplished through the development of opportunities that support the science teachers' specific commitment. Commitment through participation in on-going changes at their school is typical of all the teacher-narrators as arguments for staying in teaching, not all of these though are related directly to science teaching.

Teachers' narratives give individual stories of science teacher student recruitment, as well as retention for in-service science teachers. It is the sum of individual choices of future and active science teachers that make the recruitment and retention statistics.

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REFORM IN BIOLOGY EDUCATION: TEACHERS AND RESEARCHERS IN A PROCESS OF NEGOTIATION

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Abstract: This study reports the empirical results of the implementation of National Educational Standards in Germany and is part of the transnational European project CROSSNET (Crossing Boundaries in Science Teacher Education). In CROSSNET the term 'boundary crossing' is used as a metaphor for a professional learning process in which participants restructure their knowledge and adopt new routines. This process implies collaboration between communities which differ in their routines and practices. In this study the investigated communities are teachers and researchers who cooperate in the German project 'Biology in Context' (*bik*). *Bik* aims to promote students' competencies in context-based biology education and to support teachers' professional development. Therefore, teachers and researchers work together in Learning Communities (LCs) to transform competency models into practice. The goal of this study is to analyze the processes of boundary crossing in three different *bik* LCs. This analysis is based on Engeström´s activity theory. For the data collection the author uses interviews and protocols of LC meetings as well as instructional materials developed in the LCs. Main outcomes of the study are a better understanding of the elements and the dynamics of this activity system, including the mutual learning process of all participants around context-based and standards-based curricula – the common object of the project.

Keywords: biology education, national standards, learning communities, activity theory, boundary crossing

BACKGROUND AND THEORETICAL FRAME

Facilitating the implementation of National Educational Standards in Germany (KMK, 2004), the project 'Biology in Context' (*bik*) aims at promoting context-based and competency-oriented teaching and learning (Elster, 2009; Elster 2010). To support this goal, *bik* uses a 'symbiotic implementation approach' (Gräsel & Parchmann, 2004): teachers and researchers build Learning Communities (Brown, 1997) to put theoretically-based competence models into practice. Working together, teachers and researchers develop tasks and units, test them in the classes, and reflect on the participants' experiences and the learners' outcomes. In seeking to reform how biology is taught, *bik* puts teachers into a position where they become *'at once the targets and the agents of change'* (Cohen & Ball 1990, p.237).

In this study, the author focuses on the structure and the professional development of teachers and researchers within three independently working *bik* Learning Communities (LCs). The author examines the structure of these three LCs by analyzing teachers and researchers as different 'sub-systems'.

The theoretical frame of this analysis is based on Engeström´s activity theory (Engeström 2001) which is applied to educational research in the following way: It is assumed that a *bik*

LC is an activity system with two interacting sub-systems: the subsystem 'Teacher' and the subsystem 'Researcher' (see Figure 1). These sub-systems are the core unit of the analysis. The teacher or the researcher is the *subject* of the interacting subsystem. The initial *object* could be an idea or an assignment that triggers the collaboration of teachers and researchers. The initial object could be ambiguous, requiring interpretation and conceptualization. It could go through multiple transformations until it stabilizes as a finished *outcome*, e.g. a curriculum product. This transformation is made possible by *mediating artefacts*, both material tools and signs. Within a *bik* LC, the members continuously negotiate their *division of labour*, including the distribution of rewards. The temporal rhythms of work, the uses of resources, and the codes of conduct are continuously constructed and contested in the form of explicit and implicit *rules* (Engeström, 2001).

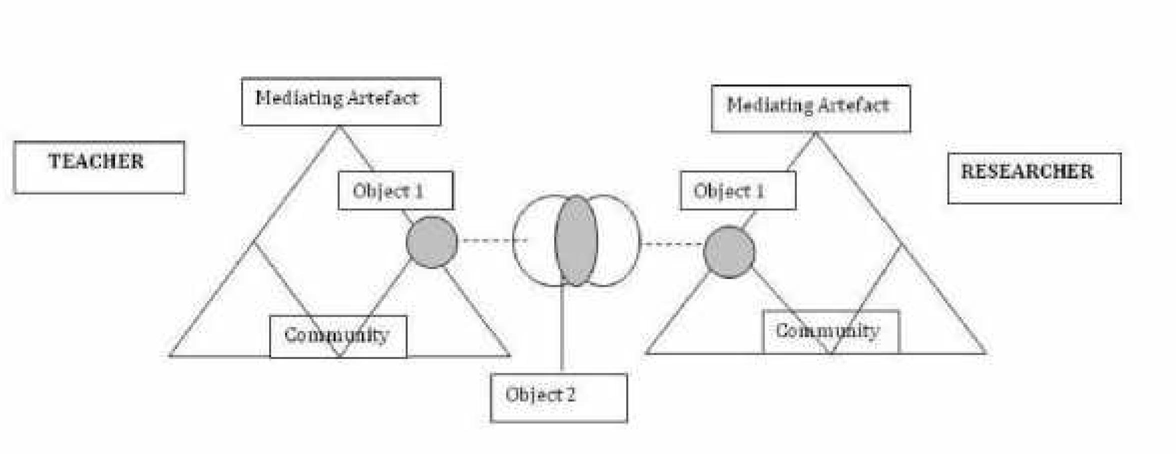

Fig 1: Model of two interacting activity systems ('Teacher' and 'Researcher'), based on Engeström's activity theory (2001, p.131)

Research Questions and Research Design

Based on Engeström's activity theory (Figure 1) the present study addresses the following research questions:

- Interacting acitivity systems: How is the subsystem 'Teacher' characterized? How is the subsystem 'Researcher' characterized?
- What are the boundaries of the participating groups and/or individuals?
- What are the outcomes of the boundary crossing process?

The organizational structure of *bik* involved the construction of Learning Communities (LCs) in the nine participating German federal states. Each LC involved collaboration among 8-16 teachers from different schools types. 144 teachers and 1689 students (aged 10 to 17 years; on average 15 years) participated in *bik*. Each LC was chaired by a coordinator and was scientifically supported by a researcher from the German Universities of Kiel, Duisburg-Essen, Giessen, Göttingen, Münster or Oldenburg. The *bik* project was coordinated by the Leibniz Institute of Science Education at the University of Kiel.

In this study, the structure and the development of *bik* in three different Learning Communities were investigated using qualitative interviews, protocols of LC meetings and analysis of instructional materials developed in the LCs. The interview combined questions about the self-concept as a teacher or as a researcher, the concept of teaching and learning, the 'ideas' regarding the *bik* innovations (concepts, theories, attitudes), the processes, rules, cooperation in the learning community. The interviews were taped and later underwent a qualitative content analysis according to Mayring (2000).

FINDINGS

The findings are structured according to the research questions by (1) analyzing the subsystem 'Teacher' (see table 2) and the subsystem 'Researcher' (see table 3). Then (3) the boundary crossing process f the participating groups and/or individuals are reported. Finally, (4) the outcomes are analyzed.

Analysis of the activity systems

Each *bik* Learning Community (LC) is seen as an activity system that consists of two interacting sub-systems, the 'Teacher' and the 'Researcher'. The individual teacher or the individual researcher is the subject of the subsystem. Pairs of teachers and researchers within an LC are the units of the analysis. These pairs are:

LC1: teacher Kathy and researcher Kim

LC 2: teacher Susan and researcher Sarah

LC 3: teacher Joe and researcher Jane

The common goal within the LCs is the teachers' and researchers' negotiation of competency models and their transfer into practice. Each LC has its own individual starting points and the initial objects (e.g. competency models) differ from each other. It is assumed that the method and strategy of how these initial objects are transformed into final objects (object 2) are different between the LCs. Object 2 can, for example, be a negotiated concept or material to promote students' competences.

Table 2. Analyzing the subsystem 'Teacher'

Sub-system	LC 1	LC 2	LC 3
Teachers	Kathy	Susan	Joe
Similarities	Biology teachers 10 – 20 years of teaching experience		
Community	*Participants:* 7 teachers from different types of school. *Cooperation:* The teachers work in 2-3 small groups on the development of teaching units. They are very critical in the selection of student-relevant contexts. *Rules :* There are no explicit rules that regulate cooperation. Implicit rules are mutual respect, trust, and punctuality. The team's discussions about norms and values are remarkable.	*Participants:* 13 teachers, mainly from High Schools. *Cooperation:* The teachers work mostly in stable pairs. The researcher Sarah presents example units. The teachers test these materials during the LC meetings and later in their classroom. *Rules:* There are no explicit cooperation rules. The teachers behave more like 'consumers' than active developers. They are 'dissatisfied' if the input is not school relevant.	*Participants:* 15 teachers from different types of school. *Cooperation:* The teachers work in school pairs or alone. The researcher (supervisor of Jane) instructs the teachers and discusses the competency model in detail. The teachers develop the materials not only during the meetings but mostly as 'homework'. *Rules:* There are no explicit cooperation rules. An implicit rule is 'reliability', i.e. that someone will do his

	Division of labour: There are group leaders among the teachers, who dominate the process. The researcher Kim is responsible for new (theoretical) input and for literature research. The coordinator is a teacher mentor who 'translates' the teachers' wishes and the researcher's demands.	*Division of labour:* The teachers behave like consumers. They are not very active in the production of new ideas. The ideas and concepts come mostly from the researcher Sarah. The coordinator is a well-accepted experienced teacher who sees herself as participant with non-extraordinary rights.	'homework' in time. *Division of labour:* The teachers develop building blocks for teaching and learning in school pairs or alone. There is only little exchange of materials among the participating schools. The supervisor dominates the teachers; the doctoral student Jane and the Post-doc Anne are his assistant researchers. The coordination is done by an experienced teacher.
Initial objects	*Units:* Bioethical themes like 'Pregnancy and abortion' or 'Organ transplantation' Typically, the teachers decide the context of the teaching units since here they are experts. The input of the researcher is about the competency model.	*Units:* Learning on stations about 'How to investigate a river?' or 'Which pet suits me and my life?' Typically, the researcher develops 'example units' and the teachers are responsible for the further development.	*Units:* Historical experiments about 'food conservation', 'photosynthesis'. Typically, the teachers develop short teaching units that 'translate' the competency model into practice in a focused manner.
Mediating artefacts	Syllabi and curriculum plans Student relevant learning contexts		

Table 3. Analysis of the sub-system 'Researcher'

Sub-system	LC 1	LC 2	LC 3
Researcher	Kim	Sarah	Jane
Similarities	Junior researchers and PhD students Aged 26 – 30 2 -3 years of teaching experience		
Community	Kim is member of a high-level research group, a graduate school, which supports her, especially in methodological issues. Her supervisor allows (or forces) her to foster autonomy and responsibility in the work with the LC 1 teachers.	Sarah is member of a research community consisting of her supervisor, a student partner and an educational graduate school. She has a special feeling for the demands of the teachers. Therefore, during the lifetime of LC2 her specific role in the LC2 changed from an assistant researcher to a well-accepted teachers' partner.	Jane's research community is dominated by her supervisor and a female postdoc. Jane receives much support from them but there is much dependence. Jane never leaves the role of an assistant and she is not really accepted as a researcher by the teachers.
Initial objects	Competence model 'valuing and decision- making	Competence model 'valuing and decision-making in environmental education for	Competence model 'knowledge acquisition in

	regarding bioethical issues'.	a sustainable future'.	the field of experimentation'.
Mediating artefacts	Example tasks *Bik* guideline for the development of tasks		

Boundary crossing in bik LCs

To analyze the processes of teachers and researchers in the *bik* LCs we use Engeström's Expansive Learning Cycle by identifying differences among the LCs regarding the identification of initial questions, the modelling of solutions, the reflection on the process, and the consolidation of new practice (Engeström, 1999).

Questioning. The initial questions of the teachers in LC1, LC2 and LC3 were about the 'new idea' of the *bik* innovation. Kathy and Susan asked for guidelines and 'cooking recipes' for the promotion of students' competences. Joe asked critically 'if there is any evidence that the competency-oriented approach is more successful than clear instructions.' The LC1, LC2 and LC3 researchers developed example tasks to make their competency-models discussable.

Analysis. These example tasks were the analysis units in the three LCs. The teachers discussed them during the LC meetings. They compared them with tasks they had traditionally used, and debated the tasks' possible learning outcomes and how the outcomes could be assessed. In LC 1 and LC 3, teachers who worked in different school types analyzed the practicability of tasks by considering the task performance in the specific school type.

Modelling new solutions. The discussions about practicability and assessment of the *bik* example tasks led to a phase of intensive production. The teachers developed new classroom materials. These materials had to be in line with student-relevant contexts and modelling competencies. Two points were remarkable: the teachers needed a longer period of time (about two to three months) to develop the first 'products' – tasks that were to be tested in the classroom. The second point was that in LC 1 and LC 2 the discourse of task development led to a power struggle among the participants and to the establishment of sub-groups. In LC 3 the researcher gave 'homework' to the teachers where they developed 'building blocks' at home and exchanged them via e-mail.

Examining the models. In the next step the newly developed tasks and units were discussed in the school teams and examined in the school classes. During the following LC meetings the classroom experiences were discussed. The researchers supported the classroom reflection by offering 'reflection sheets'. The willingness to discuss classroom experiences was higher than the willingness to write reflections. In all LCs the examination of the self-developed classroom materials led to a new prospering phase: in groups (LC1), in school teams (LC2), or in groups and by individuals (LC 3) a large number of materials were developed and tested.

Modelling new solutions. The above led to a second phase of modelling new solutions: the researchers of the LCs came together and developed a mutually shared guideline for the development of *bik* tasks. In annual meetings the teachers demonstrated their developed materials and discussed the practicability, assessment and possible impact of the *bik* tasks.

Implementation of the new model. The *bik* materials were disseminated via an internet platform and a CD Rom. The *bik* LCs invited researchers of other LCs to come to their meetings and to inform them about further competency models (e.g. the researcher of LC3 was invited by the teachers of LC2 to introduce them to the competency model of experimentation). During the annual meetings, teachers informed teachers from other LCs about their work in *bik*, and conducted workshops where they informed about, discussed, and negotiated different *bik* conforming teaching and learning approaches

Reflection on the process. The systematic reflection on the negotiation process or on the experiences during the LC meetings and the classroom experiences was a great challenge for the participating teachers. The reasons given were mostly a lack of time or 'the belief that reflection is not necessary for one's own professional development' (final interview with teacher Joe). Therefore, the guideline for *bik* task development was used as a reflection tool. With this tool each task could be analyzed to ascertain to what degree the *bik* goals had been reached.

Consolidating new practice. The *bik* outcomes were at different levels. The teachers reported 'awareness of new ways of teaching and learning' and 'new ideas'. Most of them stated their intention to implement the *bik* ideas in their classrooms, but only a few teachers changed their classroom practice fundamentally.

Further outcomes of the boundary crossing process

Changes in teaching practices. The teachers reported several motives for the change of practice. The three investigated teachers, Susan, Kathy and Joe, reported the intention to do things differently in the future (e.g. to be more aware of the students' interests, to foster students' communication skills), and the intention to continue new practices. The teachers usually expressed this intention when they had just tested and experienced a classroom experiment successfully. Although the teachers *intended* to change their practices, they rarely reported actual *changes in the classroom*. For the analysis of 'changes' we distinguish 'changed practice' from 'temporary experiments'. Only Joe reported that he had changed his practice in a more permanent way and not just for a few lessons (Joe's report). Kathy and Susan reported that they had not used the new teaching and learning approach often because 'teaching bioethical dilemmas is only for a few lessons' (Kathy's final interview) and 'students like my lessons about decision-making regarding environmental issues. They make positive remarks, but – on the other hand – I have to continue to teach according to the current syllabus' (Susan's final interview).

Changes of the competency models. In the three *bik* LCs investigated the initial competency models were changed. These changes were caused by the models' practicability and their statistical validation. In all cases the models were simplified by reducing their complexity. The reduction of complexity made the competency models easier to handle for the teachers' task development. In each LC, guidelines on how to plan tasks and units according to the competency models were developed.

CONCLUSIONS

Summarized, for the analysis of the processes within the *bik* Learning Communities, Engeström's activity theory has proved of value as a heuristic for the interactions and processes of mutual learning. The main outcome of the study is a better understanding of the elements and dynamics of the activity systems including the mutual learning process of all participants around context- and standards-based curricula (Elster, 2012).

Traces of mutual learning. The transformation of the *initial objects of teachers and researchers* (objects 1) to *finalized teacher-researcher objects* (object 2) allows the identification of traces of mutual learning: The *finalized objects* (object 2 in Figure 1) are the concrete products of the negotiation of teachers and researchers. In LC1 these are tasks and units for decision-making in bioethics (e.g. embryo transfer, medically-assisted suicide) in new student-relevant contexts. In LC2 these are tasks and units in environmental education and sustainability based on a guideline for ethical decision making. In LC3 these are building blocks to foster the competences needed for conducting experiments (generating research questions and hypotheses; planning an experiment; drawing conclusions from the experiment). Furthermore, in LC 3 a complex concept for individualization based on materials about subject-related communication is developed.

Implementation of an educational reform. Educational innovations and the implementation of educational reforms succeed or fail not only because of the teachers as 'targets and agents of change', but also because of the researchers who are shaping the reform. In the three investigated *bik* Learning Communities the 'symbiotic implementation approach' (Gräsel & Parchmann, 2004) leads to the mutual sharing of experiences and concepts, and the establishment of a win-win relationship of teachers and researchers. Based on this relationship the teachers act as partners in the educational reform of the implementation of National Educational Standards in schools. This is considered as one of the traces of success of the *bik* innovation.

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ACTIVE STRATEGIES DURING INQUIRY-BASED SCIENCE TEACHER EDUCATION TO IMPROVE LONG-TERM TEACHER SELF-EFFICACY

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Abstract: Teacher development aimed at increasing the use of inquiry based methods in schools is an important way to reach science learning goals. To this end, the EC has promoted inquiry based science teaching (IBST) within the Seventh Framework Program (FP7). One dimension, typically absent from the FP7 products, is the personal capacity belief of self-efficacy which has been shown to be important to personal behavioral change. The purpose of this research was to develop and test a model of teacher professional development (TPD) which adds specific elements for altering teacher self-efficacies to existing FP7 IBST products. This model was tested for its usefulness in increasing participant self-efficacy as evidenced by short and long term quantitative measures as well as by evaluation of long term inquiry lessons. Workshops to promote IBST were conducted in five different countries. Each workshop included strategies for increasing participant's self-efficacies. Pre and post assessments showed consistently improved personal self-efficacy scores in all of the workshops. In addition, and unlike other long-term studies of teachers, these self-efficacy scores did not significantly diminish over six months. The promotion of self-efficacy in TPD provides a consistent way of evaluating the impact of IBST workshops through the use of changes in self-efficacy.

Keywords: self-efficacy, inquiry, teacher development, long-term

BACKGROUND, FRAMEWORK AND PURPOSE

With dissemination of the results from the TIMMS (Gonzales, P., et al., 2008), PISA (OECD, 2010) and ROSE (Sjøberg, S. & Schreiner, C., 2010) studies, calls for enhanced science teacher professional development in Europe have become more urgent. Improved teacher education both in curriculum and pedagogy has been a suggested response to a lack of student interest and performance among large percentages of secondary science students (Osborne, J. & Dillon, J., 2008). Simultaneously, teacher development aimed at increasing the use of inquiry based methods in schools has been forwarded as an important way to reach these pedagogical goals (see for example, Rocard, M. et al., 2007). Partially in response to these calls for change, the European Commission has promoted inquiry based science teaching (IBST) within the Seventh Framework Program (FP7) through various projects. The plethora of useful materials developed by these and other projects all rely on effective teacher professional development (TPD) to sustainably inculcate science teachers with advanced IBST methods. To accomplish this, the projects typically rely on workshops where teachers are 'trained' in the use of the new materials with more and less success given the difficulties inherent in changing teaching cultures and procedures.
However one dimension, typically absent from TPD from the FP7 products, is the personal capacity belief of self-efficacy which Bandura (1997) has shown to be important to personal behavioral change. While research has not proven a causal relationship between self-efficacy and teaching competence, significant correlations between high teacher self-efficacies and the amenability of teachers to even attempt innovative methods have been found (Ashton & Webb, 1986; Smylie, M.A., 1990). Consequently, incorporating capacity belief change into

professional development programs seems like a worthwhile addition to the FP7 product workshops.
The purpose of this research was to develop and test a model of teacher professional development which adds specific elements for altering teacher self-efficacies to existing FP7 IBST products. This model was tested for its usefulness in increasing participant self-efficacy as evidenced by short and long term quantitative measures as well as by evaluation of long term inquiry lessons. It was hypothesized that self-efficacies could be increased through active influence and inferred that increases would help teachers carry the workshop lessons more successfully back to their teaching.

RATIONALE

Bandura (1997) showed that people act not only because they believe their actions will result in specific outcomes but also because they believe in their own ability to perform them. In science teaching, teachers with high self-efficacies are more likely to use inquiry and student centered teaching methods while those with low efficacies were more likely to be teacher directed (Czerniak, 1990).

Since teaching self-efficacy most typically declines between workshops or pre-service coursework and a year or more of teaching (Andersen, 2004) consequently, actively influencing self-efficacy during TPD may act to retain higher self-efficacies over time. Bandura (1997) established three basic mechanisms by which teacher self-efficacy may be influenced. The most important of these is 'enactive mastery experience' where success in teaching with unfamiliar methods, inquiry science for instance, reinforces future teaching. Also influential are 'vicarious experience' in which emulating the successful teaching of comparable others impacts self-efficacy as does 'verbal persuasion' in the form of credible feedback.

Active use of these mechanisms for changing teacher self-efficacy has been advocated by Bandura (1997) and others, but few studies have controlled and measured consequent effects. Bautista (2011) made extensive use of vicarious and mastery experiences to influence the self-efficacy beliefs of elementary education pre-service students. He did not use 'verbal persuasion' since he found it difficult to measure and control during a semester course. He found significant increases in self-efficacy during the study.

METHODS

Teacher professional development workshops to promote inquiry based science teaching for both pre-service and in-service science teachers were planned and piloted in five different countries. A total of 70 teachers participated in the workshops, each of which lasted from one-half to one and one-half days included strategies for increasing participant's self-efficacies. These methods using Bandura's three basic strategies for influencing self-efficacy were as follows:

Enactive Mastery Experiences

- During the workshops, participants originated and taught short inquiry lessons to their peers. They received peer-written and verbal feedback about the successful elements of their lessons as well as suggestions for improvement. In the relatively safe and supportive environment of a peer workshop, most had a successful experience with inquiry teaching.

- Participants revised traditional non-inquiry science lessons during workshops and shared their revisions with others. The affirmative feedback they received from the group about their ability to adapt traditional material to an inquiry format was part of a mastery experience.

- All were encouraged to use their developing inquiry teaching skills after the workshops with their own students. In one instance a six-month follow-up workshop was held and participants brought video of themselves teaching an inquiry lesson to their own class.

Vicarious Experience

- Each workshop included examination and analysis of short video segments of science teachers from three different countries teaching lessons which included elements of IBST. Since segments were selected to be realistic with typical teachers, participants could identify with the teachers and imagine themselves also able to do IBST teaching.
- Since each teacher taught a short 'invitation to inquiry' lesson to the workshop participants, each also got to see peers teaching successfully with IBST methods.
- The workshops were completely taught using IBST. To the extent participants could identify with the instructor, they could vicariously imagine themselves also using IBST.

Verbal Persuasion

- During participant IBST teaching, both to the workshops and in one case to their own students, their peers and instructor emphasized the successful elements of their lessons and offered ideas for improvement.
- Feedback to transformed traditional lessons from both peers and the instructor focused on changes consistent for IBST and offered credible further alterations.

Quantitative measures of self-efficacy were made of all participants using the widely used STEBI instrument (Enochs, L.G. & Riggs, I.M., 1990). Both pre-and post-workshop measures of self-efficacy were taken. In the long-term follow-up workshop where participants shared videos from their own classes in which they taught using IBST, self-efficacies were again measured. Observed instances of inquiry teaching both live and via videos were scored for inquiry based on the Science Learning Cycle Rubric developed by Goldston, M.J. et al. (2010).

RESULTS

Participant feedback from the workshops was classified according to Bandura's three basic strategies for influencing self-efficacy. Their comments begin to validate the method of active self-efficacy enhancement in that the participants recognized personal benefits from each of the three strategies. These are examples of the grouped comments:

Participant comments relating to enactive mastery experiences

'The preparation leading up to making the video involved a lot of discussion and planning. As a result I felt that it pushed us to explore the area more deeply. This is a good thing. I think this stage was a good one if the time is available to do it properly.'
'Really good! Yes, such elements should be part of every teacher's education. Working in small groups on preparing has amazing affects on deep discussion of goals and means to achieve them.'
'To feel your own body, what works and what captures you.'
'Always useful because it gives experience. Feedback was good! '
'Involving! Group discussions result in good ideas.'
'This was useful. It is about making it practical and discussing it.'
'Important to try oneself- having to think a bit further. Something that we are not always good at.'
'Useful to find own examples. Easier to change my own teaching after this.'

'Own experience and discussions after words were useful. Good to see what others do … gives ideas.'
'Liked the idea with a way of reflecting on the steps I do things like body language and voice.'
'Effective and to the point! Performance is reformed by seeing ourselves in action with these goals. It was just 'perfect'. Teachers were natural.'
'Fun to test yourself under pressure.'
'Good thing so less confident people get to experiment with their teaching style. But go to live teaching shortly afterwards.'

Participant comments relating to vicarious experiences

'*The videos worked really well. Communication in the classroom is very rich and the videos captured this, particularly the dynamic aspects.'*
'Videos are very good for discussion so keep those in the modules. Instruction was clear and time sufficient.'
'It is useful to have an example in common to talk from.'
'Fine to see real teachers in real situations. Good that it is not results we see but something to discuss.'
'Ok to start discussions…nice to see 'real' teachers and pupils.'
'I learn how to do it by watching. How to spend time and talk to students.'
'A concrete starting point for discussion.'
'Examples of unknown teachers allow free and open discussions of good and bad.'
'Good way to have a common things to talk about. Easier to begin with others.'
'Very useful. Group work was very beneficial to apply things.'
'To see what is good teaching and what is not. See how students react to both kinds. Discussing how to make bad teaching better. It was all great and very useful. Most interesting and best part of the day.'

Participant comments relating to verbal persuasion experiences

'Always useful because it gives experience. Feedback was good! '
'Own experience and discussions after words were useful.'
'Liked the idea with a way of reflecting on the steps I do things like body language and voice.'
'Good thing so less confident people get to experiment with their teaching style.'

Relative scores on the self-efficacy instrument varied between workshop participants along with their teaching experience and cultural milieu. Quite consistently in all of the workshops however, pre to post workshop scores increased regardless of the original scores. Since the long-term effects of IBST workshops are of particular interest, a group of participants in such a workshop were followed and examined as case-studies. In these cases, pre and post STEBI scores were taken at the start and conclusion of a two-day workshop and again six months later at a follow-up workshop. In addition, participant videos of teaching in their own classrooms were scored. An example of two of these followed cases:

Participant A. During this in-service teacher's participation in the original two-day workshop their relatively high STEBI scores went from 100 to 104 and in the follow-up workshop eight months later, remained relatively high at 106. Consistent with this stability was the rating of 7.5/10 on a video of his teaching. They showed particular strength in providing continuous feedback to the students as they 'inquired' and in maintaining a 'learning cycle' sequence to his lesson. The teacher's students were engaged in an exploration of content which required original thinking in non-formulaic ways. With minimal instructions and an acceptance of varied solutions, the teacher gave the students opportunities for genuine inquiry and rewarded their efforts by using their solutions for the problem resolution. The teaching was very consistent with the workshop aims.

Participant B. This teacher's relatively low self-efficacy score compared to the group went from 84 to 88 during the initial two-day workshop and was stable at 87 in the eight-month follow-up. However, the teacher's inquiry teaching video was rated at 7.0/10 based on a particularly strong student engagement using real world links to student's daily lives. The teacher also had a good extension and feedback. However, the teaching was notably weaker in the inquiry exploration and explanation.

CONCLUSIONS AND IMPLICATIONS

The use of active strategies to enhance self-efficacy during workshops has been validated through pre and post assessments which showed consistently improved personal scores in all of the workshops. However, unlike a previous long-term study of teachers, this study's self-efficacy scores in the long-term instance did not significantly diminish during the intervening six months (Andersen, A.M. 2004). If through repetition, the active uses of Bandura's (1997) methods for increasing teacher self-efficacy prove to be effective, then their wide-spread addition to IBST modules may be validated. This on-going study's results also provide a consistent multidimensional way of evaluating the impact of IBST workshops through the use of changes in self-efficacy of participants as well as success at using inquiry after workshops back in classrooms. Both outcomes would increase the efficacy of workshop products of EC projects.

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SO WHAT IS IT? MAKING SENSE OF THE COMPONENTS THAT CONTRIBUTE TO EFFECTIVE PRIMARY SCIENCE TEACHING

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Abstract: Teachers are key players in the reinvigoration of science education. Unfortunately, the spotlight is often shined on the shortcomings associated with teaching and learning in science. If the status and quality of science education in schools is to improve, efforts need to be made to better understand the classroom practices of effective science teachers.

In a step towards better understanding, the doctoral study gathered evidence examining what two effective primary teachers were doing to promote student engagement in science over a term long sequence of lessons. Evidence of their effective science teaching was gathered primarily through a video-based approach and was supplemented with teacher and student interviews, and student work samples.

Several themes were identified as characterising the practices of these two teachers. These themes form the basis of a conceptual model, which was developed to highlight the various components contributing to effective primary science teaching practices. In teasing out these components, this paper will examine how the teachers' beliefs, knowledge and practices, as well as the contextual factors inherent in their classroom environments, influenced how and why they teach science in the ways they do. While care must be taken in generalising from two cases, these findings have implications for primary science teachers, teacher educators and curriculum developers.

Keywords: primary science education, effective practices

BACKGROUND, FRAMEWORK AND RATIONALE

With trends across many countries still indicating the decline of student interest in school science and diminishing numbers of students studying science beyond the compulsory years, it seems that the field remains in crisis. In recognition of the impact that teachers have on student learning (Hattie, 2003), changes to this situation would need to come from teachers who are qualified and committed to science (Goodrum, Hackling, & Rennie, 2001). If these changes are to be realised, an understanding of what constitutes effective science teaching is required and should be addressed.

Reflecting the context of this study, there are three key research documents that have identified characteristics of effective science teaching in Australian schools. These documents are the *National Review into the Status and Quality of Science Teaching and Learning in Australian Schools* (Goodrum et al., 2001), the *Professional Standards for Highly Accomplished Teachers of Science* (ASTA and Teaching Australia, 2009), and the components of effective science teaching as developed by the *School Innovation in Science (SIS) Project* (Tytler, 2003). These three documents provide rich, detailed descriptions of what characterises the strategies, attributes and environments of effective science teaching practices. The frameworks that these studies provide are useful tools in better understanding the different aspects of effective science teaching and learning. In their synthesis of these documents, Hackling and Prain (2005) identified a strong convergence around six characteristics of effective science teaching:

1. students experience a curriculum that is relevant to their lives and interests;
2. classroom science is linked with the broader community;
3. students are actively engaged with inquiry, ideas and evidence;
4. students are challenged to develop and extend meaningful conceptual understandings;
5. assessment facilitates learning and focuses on outcomes that contribute to scientific literacy; and
6. information and communication technologies are exploited to enhance learning of science with opportunities to interpret and construct multimodal representations.

(Hackling & Prain, 2005, p. 19)

However, while these identified components may help to shed light on the nature of effective science teaching, on their own they cannot bring effective science teaching to life. Effective science teachers may be able to demonstrate particular attributes, but little is understood about precisely what beliefs and knowledge drive their practice. Therefore, it is not clear why effective teachers' actually do what they do.

The overall purpose of this doctoral study was to collect evidence about what effective primary science teaching looks like over a term long sequence of lessons and to explore the relationships existing between teachers' beliefs, knowledge and their practice. This paper will report on the findings gathered from two primary school science teachers involved in this study, Deanne and Lisa. In particular, the following research question will be addressed: what characterises the practice of an effective primary science teacher?

METHODS

This study was qualitative in nature and incorporated ethnography with an interpretive case study approach (Merriam, 1998). These methods were used to reflect the complexities inherent in teaching and in coming to better understand the practice of teaching, as well as to allow for the recreation of a rich and vicarious experience for the reader (Peshkin, 2000). This section provides an overview of the research design used for this study by outlining the participants and data gathering techniques used during the data collection process.

The participants in this study were two primary school teachers, identified as effective practitioners of science by a professional colleague, and their students. At the time of the study, Deanne was teaching a Year 7 class and Lisa was teaching a Year 3 and 4 class. Year 7 is the final year of primary school in Western Australia, the Australian state where this research was conducted. A focus group of four students was formed in each class.

Observations were carried out in each teacher's classroom over one school term (10 weeks) during their weekly science lessons (each approximately one-and-half hours in length). Three video cameras captured each science lesson with one camera tracking the teacher, one camera focused on the focus group students, and the other camera was fitted with a wide-angle lens to focus on the whole class. Following each classroom visit, semi-structured interviews were conducted with Deanne and Lisa with each interview approximately 40 minutes in length. The focus group students from each class were also interviewed after each science lesson. These students were interviewed as a group with each interview taking approximately 10 minutes. Written documents were also collected from the two teachers and their students over the unit, such as unit plans, worksheets, assessment items and work samples.

The data collected from the multiple sources were examined for the practices characterising Deanne and Lisa's approaches to science teaching and learning. A process of ethnographic microanalysis, as described by Erickson (1992), was used to analyse the data from the video footage, interview transcripts, and work samples. Data sources were watched or read several times and events, episodes and quotes were identified that provided supporting evidence for the emergent themes. Several themes emerged from the data and were identified through being mentioned or observed numerous times. The emergent themes were presented to both teachers for further clarification.

RESULTS

This research resulted in five general assertions (GA) being developed to describe the influence of effective science teaching practice on student learning in science. These five general assertion were:

- GA 1: Teaching for student engagement in science;
- GA 2: Providing students with concrete experiences in science
- GA 3: Supporting student learning in science
- GA 4: Monitoring students' learning in science
- GA 5: Developing scientifically literate students

The model below (see Figure 1) was synthesised from the general assertions that emerged from the analysis and interpretation of the multiple data sources. This representation identifies the interacting components that characterise the similarities inherent in the effective science teaching practices of the two teachers.

The components of the model are described, in relation to the five general assertions, in the following text. Deanne and Lisa used concrete experiences of science to provide students with opportunities to explore science phenomena first-hand (GA 2), engage in meaningful talk about science (GA 3) and provide a context for the construction and use of multi-modal representational forms (GA 3). They actively monitored these learning experiences and provided students with constructive feedback regarding their learning (GA 4). These components are embedded within inquiry-based approaches to science teaching and learning, which acted to promote student interest and engagement (GA 1). Through nurturing student understandings and positive attitudes towards science (GA 1), Deanne and Lisa supported students in becoming scientifically literate citizens who are capable of engaging with science issues relevant to their lives and their communities (GA 5). Underpinning these practices are beliefs, knowledge and contextual factors, which directly impact on teachers' orchestration of learning to meet their particular students' needs in the contexts in which they work.

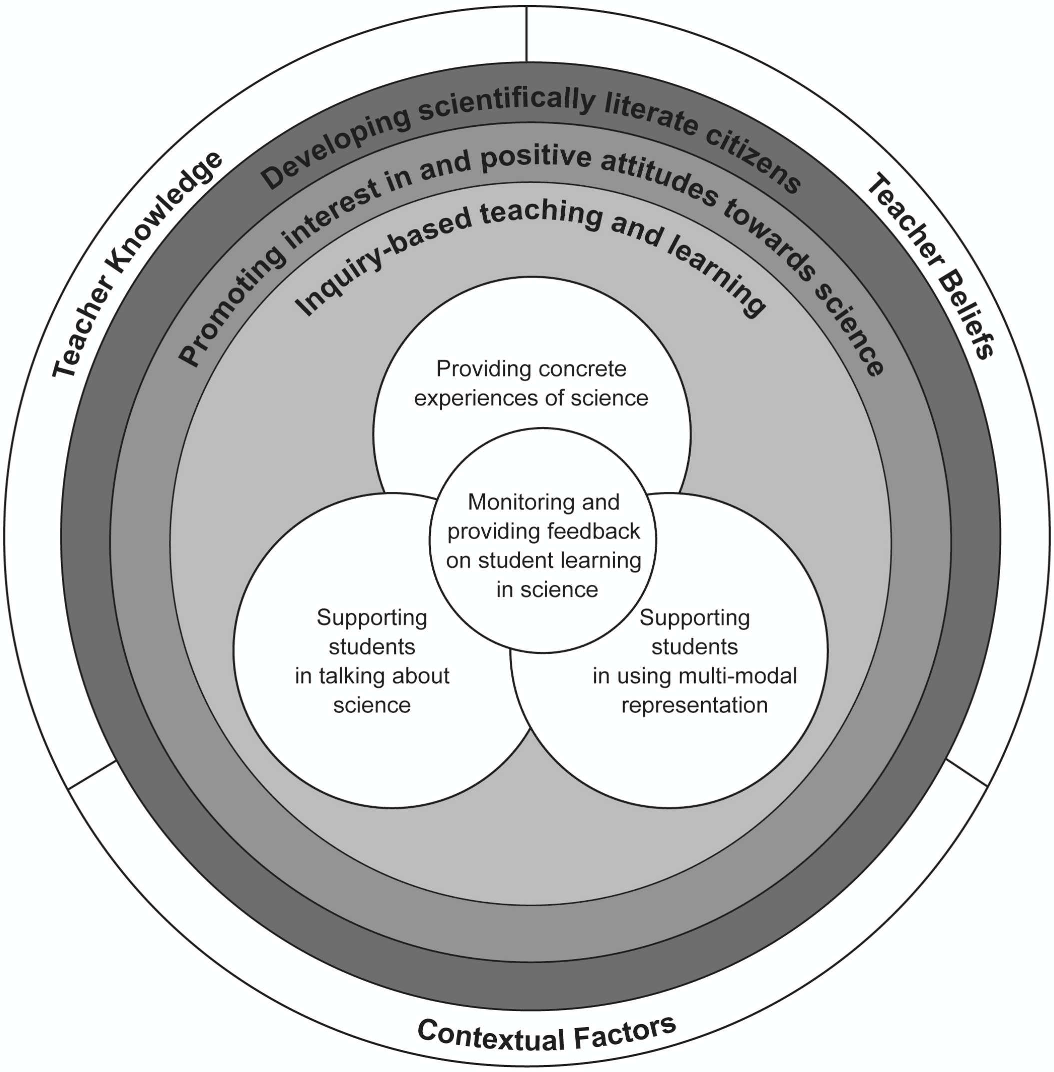

Figure 1. Conceptual model of components contributing to effective primary science teaching

CONCLUSIONS AND IMPLICATIONS

The tendency for primary school teachers to avoid the teaching of science has been well documented (e.g., Tytler, 2007). Research has suggested that as little as three per cent of teaching time, on average, is allocated to the teaching of science in Australian primary schools (Angus, Olney & Ainley, 2007). Other research has demonstrated that interest in and attitudes to science learning are entrenched in 14-year-old students (e.g., Lindahl, 2007). When combined, these findings concern all stakeholders in primary science education. The primary school years are therefore a crucial time for capturing students' interest in science and the development of understandings of what constitutes effective science practices in the primary setting are of key importance. While this research contributes to the existing knowledge base and literature, a more comprehensive understanding of what constitutes effective primary science teaching and how it is influenced by teachers' beliefs and knowledge, as well as contextual factors, is needed if we are to better support primary school teachers in the practice of teaching science.

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INNOVATIVE SCIENCE TEACHERS: WHAT THEY HAVE IN COMMON

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Abstract: Changes, in general, in science education require that teachers play an additional role different from their traditional model. However, in Brazil teacher education policies do not provide the necessary conditions for changing the role of the teacher. In the Brazilian context, at least for public schools, science teachers do not have many opportunities for innovative practices as there are a number of factors that can prevent it from occurring. Nevertheless, even in this unfavorable context, some science teachers create new ideas (e. g. curriculum development projects), and innovate their pedagogical practices. This study seeks to identify professional characteristics of innovative science teachers that even without support or time, they innovate their pedagogical practices. We used different research techniques including open-ended and narratives interviews (2010) and participant observation with two science teachers from elementary schools. The teachers were observed for three years (2008-2010). The data showed that these professionals have some characteristics in common: they create innovations by themselves; participated in new school' curriculum development projects, they regularly participated in continuing education programs, they were more motivated to enhance their daily pedagogical practices, and they had a social commitment to students. Understanding these professional characteristics can assist school principal and pedagogical coordinator to promote, encourage, and support science teachers in creating and participating of innovation.

Keywords: Innovation. Changing. Science teachers.

INTRODUCTION

Changes in science education require that teachers play another role different from a traditional way of teaching. However, in Brazil the teacher education policies do not provide the necessary conditions for changing teachers' practices. Thus, science teachers in most classrooms do not innovate and change their pedagogical practices, related primarily to traditional content exposure, and the use of traditional pedagogical tools such as blackboards and textbooks.

Innovation is defined as a set of interventions and decisions with a certain degree of intentionality (FULLAN, 2001; CARBONELL, 2002; CARDOSO, 2003). According to Carbonell (2002) it can be used to stimulate theoretical reflection of the teachers' experiences and promote interactions among students.

Many factors influence innovations. Among them are: culture of school, teachers' conceptions regarding teaching and learning.

In another study (Garcia, 2009) it was demonstrated in a Brazilian context that some factors prevent science teachers practicing innovation (e. g. lack of time to discuss the problems of implementation and the development of innovation in school). This is opposite to the simplistic view from that tend to blame science teachers for lack of innovative practice. Others factors that also prevent innovations are the poor working conditions, new laws that overload teachers' practice with more assignments and responsibilities, traditional pre-service education program, the role of principals in schools, and the teachers general lack of knowledge and beliefs in innovations being proposed.

Nevertheless, even working in unfavorable contexts for change some science teachers seek new alternatives, and in fact do innovate.

We believe, as Cardoso (2003), that there are many variables involved in the process of teacher-as-innovator. These include: *organizational factors* (those linked to encouraging climate that can favor personal initiative), *professional* (those related to professional activities); *personal* (those linked to teacher' attitudes related to innovation receptivity) *demographics* (gender, age, work experience), and *personality* (linked to a greater or lesser predisposition to innovation).

In this study we are particularly interested in identifying professional characteristics (variables) that are common about science teachers' daily pedagogical practices. Understanding these professional characteristics can assist school principal and pedagogical coordinator to promote, encourage, and support them at school, favoring, in this way, science teachers to create and participate of innovation.

TEACHERS AND INNOVATIONS

Despite its ambiguous character, innovation refers to a set of interventions and decisions with a degree of intentionality and systematization, which aim to transform attitudes, ideas, culture, content, pedagogical models and practices (FULLAN, 2001; CARBONELL, 2002; CARDOSO, 1997).

The implementation of innovations, according to Fullan (2001: p. 75-80), is affected by a set of interactive features. Among others, is the need for change and clarity about the goals and objectives. Innovation also depends on the culture of the school, the teachers' conceptions about teaching and learning, and still need time and support to be implemented.

In recent years, reforms and innovations implemented by governments have failed to transform, for example, science teachers' practices that continuing being traditional. This is because, in part, in Brazil policies for teacher education have not produced the necessary conditions for a significant change in the role of the teacher. Many science teachers, however, have the desire to change, but they are working in systems, schools, and with professionals who do not promote innovation, and often even functioned as obstacles to change (GARCIA, 2010).

Some authors have already identified some obstacles related to innovation. Among them are the overload of work (HARGREAVES & FULLAN, 2000), individualism of the profession (HARGREAVES & FULLAN, 2000; THURLER, 2001), organization and operation of the school (THURLER, 2001), the meaning of innovation (HARGREAVES, EARL & RYAN, 2001; THURLER, 2001, FULLAN, 2001), the issue of time to perform the change (HARGREAVES, EARL & RYAN, 2001; CARBONELL, 2002; FULLAN, 2001), lack of support for teachers make concrete changes (FULLAN, 2001; CARBONELL, 2002), the way the school principal work (THURLER, 2001), the reflection of failed innovations on future projects (HARGREAVES & FULLAN, 2000; THURLER, 2001), lack of time to discuss the problems of implementation and the development of innovation in school (GARCIA, 2009).

Garcia (2009, p.55) identified some factors that difficult science teachers to innovate: personal factors (lack of interest in participating in the project, fear, insecurity), professionals (lack of encouragement, support and time, inability of those who run the project, overwork and lack of learning) and contextual (lack of material and financial resources).

However, it is worth noting that some science teachers, even working in some unfavorable contexts with many obstacles, as described earlier, they still innovate in their classrooms. They have a change as an integral part of what they believe in their work. Create new practices, being receptive to others, participate in projects is part of what they believe about teaching and learning. In other words, innovation is part of their personal views of teaching and learning in schools.

Beside this, in a study about pedagogical innovations at the university, Cunha (2004) showed that teachers who innovate have some common characteristics. They enjoy teaching, are dedicated to their work, more enthusiastic about their practices, more critical and satisfied with what they do, and have a social commitment to students and to school community.

Cardoso (1999), on the other hand, tried to understand the correlation between teachers' receptivity to innovation associated with other variables such as experience in teaching and continuing education. The author found, although weak, positive correlation between continuing education, (in terms of participation in courses (congresses, conferences), publishing scientific articles, and research projects inside and outside the school), and receptivity to innovation. That is, teachers with greater participation in these three levels also had more favorable attitudes to pedagogical innovation.

METHODS

This study aims to identify common professional characteristics in two science teachers who innovate constantly in their teaching practices. To answer this question we selected two science teachers who work in elementary education in public schools in Sao Caetano do Sul, a province/state near Sao Paulo - Brazil.

These two teachers were selected from a group of 20 teachers who taught in elementary public schools. Our choice was based on their classroom performances in schools and specifically their teaching of science classes. These teachers regularly created innovative pedagogical practices, participated in other school-based initiatives, they were constantly involved in continuing education, and also involved in activities with their students, which included field trips.

Data were collected through participant observation and interviews. It is worth noting that the researcher was also the responsible for promoting science continuing education for these two teacher participants and, therefore, spent three to five hours per week with them.

The observations were conducted for approximately three years, once a week (on alternate days) for duration of two hours. The observations were made using protocols of research adequately developed to collect information on: 1) number of innovations created, 2) participation in the school's innovations, 3) participation in continuing education projects, 4) involvement with students, 5) involvement with parents, and 6) professional connections.

The interviews (2010) collected information on 1) teachers’ profile (gender, age, education, teaching experience, teacher workload, per week), and 2) on the teachers’ triggering reasons to innovate. Narrative interviews were also conducted in order to understand more about their personal and professional trajectories, however these data are still being analyzed.

We also interviewed:

- A) a group of 10 students about these two exceptional teachers in 2008, 2009, and 2010 (different students each year) to know: 1) students' view over his/her teacher, 2) students' view over his/her teacher' classes (his or her pedagogical practices) 3) students' view over the relationship between them.
- B) the pedagogical coordinator from both schools.

RESULTS AND DISCUSSION

The participants were one male (55 years-old) and one female (45), both with over 20 years of teaching experience. His undergraduate degree majored in Science and Biology, and worked in two public schools and with a workload of 45 hours-class per week. She majored in Science and Chemistry, worked in a public school with 26 hours-class per week. Both had experience with some postgraduate science courses.

From the interviews we highlight the reasons about their willingness to engage in pedagogical innovations. With very similar responses, both research participants attributed this approach to innovation based on their beliefs about education; that is, their conceptions of teaching and learning, which was also confirmed by observations. They valued and believed that innovations could motivate students and at the same time improve their pedagogical practices. This finding was also found by Anderson (1989) when he affirmed that the conceptions act as personal theories that lead, among other things, pedagogical practice of teachers.

From interviews we highlight two other results that are explained below:

She indicated that she could be innovative because the school's atmosphere offered a perfect scenario to create new curriculum and pedagogical projects. He, on the other hand, stated that he used to innovate because that was part of his daily life. This reason may be linked to his personality and not necessarily to his views of education. The narrative interviews which we are still analyzing may explain more about this finding. It is interesting to note that both teachers were enthusiastic about teaching science, and had a social conscious about students as it was already described by Cunha (2004). This commitment was expressed, among other things, meetings with students inside and outside working hours, educational programming outside of school with students, with respect to organizing and supervising visits with students to museums.

Data from observations showed that the two teachers created at least one innovation each year. They also participated in any new school projects being organized during every year of the observations. They were constantly engaged in continuing education in their workplaces. The male participant was involved in independent professional development courses at universities as well. In fact, teachers-as-learner was a permanent characteristic of both teachers. This again confirms what Cardoso (1999) found in her quantitative study about the positive correlation between continuing education and the receptivity to innovation.

Both participants were regularly trying to find new contents from newspapers, scientific journals to bring to their students. They were commonly involved with their students, although he promoted more pedagogical studies outside the school. They knew, for example, students' name, students' difficulties and had good teacher-student relationship with them. They were viewed by their students as being more democratic and good teachers in general. Finally, these professionals had contacts with networks of collaborators outside the school, generally associated with colleges and universities.

The school and the school principal also considered them excellent teachers. They were, generally, in the school staff meeting more critical they asked more questions, and discussed and criticized the ideas that were being discussed.

Interviews with the two pedagogical coordinators (PC) of schools showed that they also considered the two teachers as innovators, because they were always "creating, inventing, taking part in something at school or community" (PC01). One of the coordinators also said that in school meetings the teacher demonstrated to be more critical and has a more elaborate discourse about pedagogical practices (CP02).

FINAL IMPLICATIONS

We highlight some professional characteristics that are common in both teachers: 1) involvement with continuing education, 2) motivation with the pedagogical practices and 3) social conscious about their school community.

These professional characteristics have direct implications for school principals and pedagogical coordinator for the school and school district. School and district administrators can act to promote a better atmosphere to develop, encourage, and support these professional characteristics at school amongst all teachers. This will help science teachers to gain confidence and begin pedagogical and curricular innovations and, at the same time, participate with other teachers with the objective of assisting students in their process of learning science in schools.

On one hand, the implications of those conclusions bring the need to ensure a deep understanding of several variables involved in innovation process. On the other, it indicates that larger investments in the quality of science teachers' initial and continuing education especially in support to school-based professional development, may favor science teachers in the process of creating innovative pedagogical practices.

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HOW DO IN-SERVICE TEACHERS EVALUATE THE COGNITIVE/LINGUISTIC SKILLS IN THE STUDY OF ASTRONOMY?

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Abstract: The aim of this study is to find out how teachers of the last years of Primary and the first years of Secondary evaluate and what difficulties they find in relation to a series of cognitive- linguistic skills (description of facts and observable phenomena, description of theoretical models and justification of the phenomena using theoretic models). It also aims to find out whether teachers establish differences when the skills are expressed in a general sense or when they are associated to the subject of astronomy.

In the study, 113 Primary and Secondary teachers from different centres in Galicia (Spain) who responded to a closed survey took part. The results show that the teachers positively evaluate the skills presented, with changes being seen in terms of content. The description of facts/phenomena is considered more in generic terms and those skills which require more abstraction, in astronomy terms. The teachers attribute more difficulty to the latter skills in the generic principles than in the astronomy ones.

The few differences between the groups of teachers are in the evaluation of the description of models and in the difficulty attributed to some skills that require more abstraction from the primary group.

Keywords: Teaching thought. Active teachers. Primary. Secondary. Astronomy

INTRODUCTION

Communication is very relevant in the teaching of sciences (Jiménez Aleixandre, 2003; Mortimer, 2006). For this reason, the development of different cognitive-linguistic skills is important, such as for example: the description of a fact or phenomenon; of a theoretical model and the justification which explains why this phenomenon is produced, by using an accessible theoretic model with students of a certain age (Jorba et al., 2000). They are all necessary and they should be promoted in different subjects in a balanced manner. There is no sense in teaching a model if it is not going to be used in order to justify an act/phenomenon.

In particular, in the subject of astronomy the description of the models (Earth rotation/ passage) is insisted on more than the observation of the sky. Teachers may feel uncomfortable focusing their attention on the direct observation of the movement of the stars throughout the day and night as this involves carrying out a geocentric interpretation. Therefore, it is immediately clear that what we observed is not “right” (Shen & Conferí, 2010). However, despite the importance that teaching staff seem to give to knowledge of the theoretical models, they have difficulty in working properly with the model in the classroom (Justi & Gilbert, 2002).

The teachers' way of thinking is an important factor in the change and improvement of teaching, therefore knowing their opinions is essential for improving their professional development and the quality of teaching (Van Driel, et al. 2001; Mellado, 2003).

In accordance with the aforementioned, our objective is to find out how practicing teachers in the last years of Primary and the first years of Secondary evaluate certain cognitive-linguistic skills when they are expressed in generic terms and when they are associated to astronomy content. We also intend to find out the difficulties the teachers attribute to these skills.

METHODOLOGY

A closed survey was carried out of 113 practicing teachers (59 from the last year of Primary (students from 9-11 years old) and 54 from the first year of Secondary (12 to 14 years old), from different schools in Galicia (number of teachers per centre always <3).

The participants evaluated on a scale of 1 to 5, the importance and difficulty of some language-related skills: description of facts and/or phenomena, description of a theoretic model and their justification. The skills were stated generically and they were associated to their knowledge of astronomy. Specifically, the teachers had to evaluate the importance and difficulty of generic abilities expressed in the following terms: a) "describe facts and natural, observable, everyday phenomena, such as the movement of objects, changes of state, rainbows, etc."; b) "describe un-observable processes, such as digestion in human beings, or describe more or less simple scientific models, such as a model of a cell or the Earth, etc."; c) "justify facts or phenomena by using a more or less simple scientific model, such as justifying a change of state using a particles in movement model or justifying the phases of the moon with the Sun/Earth/Moon model". Furthermore, the teachers had to evaluate the importance and difficulty of cognitive-linguistic abilities which involve the expression of certain astronomic statements about daily and annual changes. The statements were the following: a) *"The Sun moves in the sky from east to west throughout the day"* and *"In areas with mild climates there are seasons and the number of daylight hours and the height of Sun varies throughout the year"* (these statements involve the description of facts/phenomena); b) *"The Earth is a spherical shape, it rotates on its own axis"* and *"Earth with its inclined rotation axis revolves around the Sun"* (these statements involve the description of models) and c) "*The sun seemingly moves through the sky during the day because the Earth rotates around itself*" and "*In temperate zones of the planet, both the number of hours of light and darkness and the height of the sun at midday change regularly throughout the year, due to the inclination of the Earth's axis and its movement around the sun*" (these statements involve justification). The summary of statements and codes can be seen in Table 1.

In the analysis of results the following was used: a) the McNemar test in order to detect differences between the maximum evaluation/difficulty granted to the different principles within each group of teachers and b) the Pearson χ^2 in order to identify differences between both groups. The statistics programme SPSS was used (significance value $p<0.05$). An individualized analysis of the evaluations of each teacher was also carried out, independently of the evaluation, in order to see which skill was granted higher importance or level of difficulty (see types of evaluation, Figures 1 and 2).

RESULTS

The majority of the teachers gave the maximum points to the different principles. All of them receive a value 4 or 5 from more than 50% of the teachers (Table 1). Significant differences can be seen between the principles, in particular: a) in the generics, G-FD is more important that G-MD in the Primary group (p=0,001); b) in the daily changes, D-MD taken more into consideration in the Primary group (p=0,031; p=0,022) and more valued that D-FD, in the

Secondary (p=0,049) and c) in the annual changes, A-FD is valued more than A-MD in Primary (p=0,031). When comparing the generic and astronomic principles, it can be seen that in Primary D-MD is more valued than its generic counterpart (G-MD) (p<0,000) and in Secondary the opposite occurs with D-FD (less valued than G-FD) (p=0,04).

Table 1. Teachers who award maximum importance and difficulty (values 4 and 5) to the different principles (generic and astronomy)

Category/Principles		**Importance**		**Difficulty**	
		Prim.	**Secon.**	**Prim.**	**Secon.**
Generics	G-FD Describe phenomena and natural facts	49(1) (83.1%)	45 (83.3%)	23 (39.0%)	13 (24.1%)
	G-MD Describe models or non-observable processes	34 (57.6%)	44 (81.5%)	44(1) (74.6%)	37(1) (68.5%)
	G-J Justify facts and phenomena using a simple model	38 (64.4%)	41 (75.9%)	44(1) (74.6%)	32(1) (59.3%)
Daily changes	D-FD The Sun moves in the sky from east to west throughout the day	43 (72.9%)	32(2) (59.3%)	28(1) (47.5%)	18(1) (33.3%)
	D-MD The Earth is a spherical shape, it rotates on its own axis	53(1)(2) (89.8%)	41(1) (75.9%)	15(2) (25.4%)	6(2) (11.1%)
	D-J The apparent movement of the sun is explained by the Earth's rotation	44 (74.6%)	36 (66.7%)	31(1) (2) (52.5%)	18(1)(2) (33.3%)
Annual changes	A-FD In areas with mild climates there are seasons (nº of hours of light and height of Sun varies)	39(1) (66.1%)	40 (74.1%)	20 (33.9%)	10 (18.5%)
	A-MD The Earth with its inclined rotation axis turns around the Sun.	30 (50.8%)	40 (74.1%)	41(1) (69.5%)	16(2) (29.6%)
	A-J The seasons are due to the inclination of the axis of the Earth and to its passage	32 (54.2%)	36 (66.7%)	39(1) (66.1%)	30(1) (55.6%)

(1) Assessment/consideration of difficulty significantly higher than all or some of the principles of their category (test McNemar; p<0,05)

(2) Assessment/consideration of difficulty significantly differs from its generic counterpart (test McNemar; p<0,05)

The teachers recognize difficulties, detecting the following differences: a) in generic principles, G-MD and G-J are more difficult for both groups (p<0,000); b) in the daily changes, D-MD is more simple for both groups (Primary p=0,004; Secondary p=0,008) and c) in the annual changes, A-MD and A-J in Primary and A-J in Secondary are considered more difficult that A-FD (p=0,002). Moreover, the secondary teachers see more difficulty in the more abstract generic principles (G-MD and G-J) than in their astronomy counterparts (p<0,000) except in the case of AJ. The same happens in the Primary group, but only for daily changes (D-MD p=0,000 and D-J p=0,02).

Using the Pearson χ^2 test, differences are detected between the groups of teachers. The principles G-MD and A-MD are more important for the Secondary group (p=0,006; p=0,01) and D-MD for the primary group(p=0,048). The principles D-J and A-MD are more difficult for the Primary teachers (p=0,04 and p<0,000, respectively).

The comparative analysis of the evaluations of each teacher (Figure 1), shows that for the two groups, type A (the description of facts/phenomena is valued more) is the most frequent in the generic principles. However the frequency decreased in the case of the astronomy principles (daily changes in both groups and annual changes in Secondary). With regards to difficulty (Figure 2), type B (the abstract skills being more difficult) is the most numerous in the generic principles and in the annual changes. However, in terms of the daily changes, more than 40% of the subjects show type A opinions.

Figure 1. Percentage of teachers that: **A** (value FD more than MD and/or J; **B** (value MD more and/or J than FD); **C** value all the principles equally

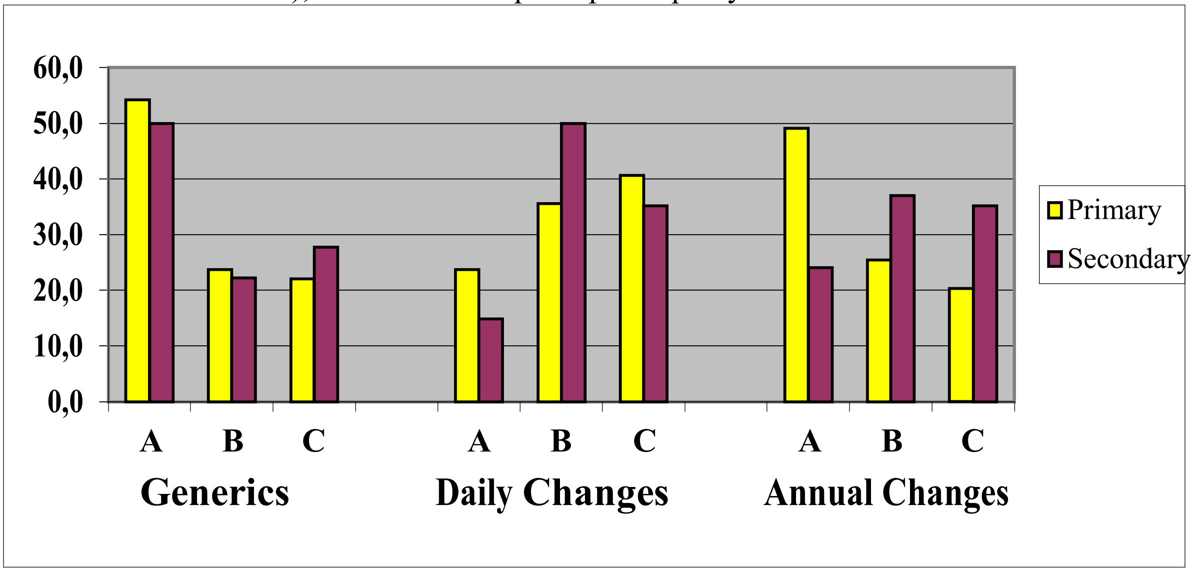
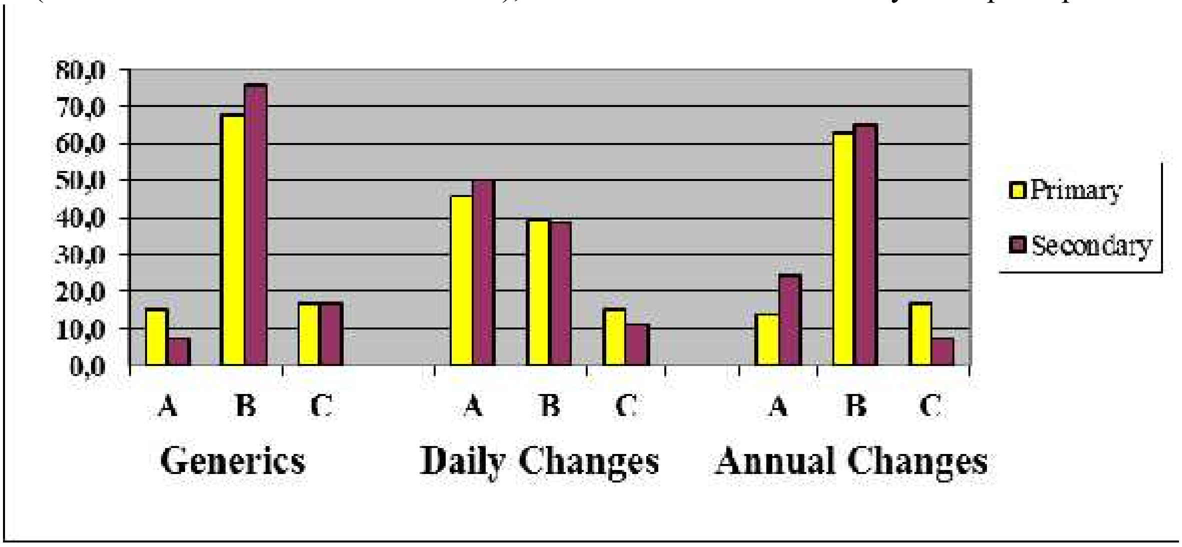


Figure 2. Percentage of teachers that consider: **A** (FD more difficult than MD and/or J); **B** (MD and/or J more difficult than FD); **C** the same level of difficulty in all principles



CONCLUSIONS

The teachers positively evaluate the cognitive-linguistic skills, seeing differences in accordance with the content. In general, the description of facts/phenomena is considered more in generic terms and the skills that require more abstraction are valued more in relation with astronomy knowledge.

The teachers attribute more difficulty to generic skills that require more abstraction than their counterparts associated with astronomy aspects.

Few differences are detected between the groups of teachers. They focus on the evaluation of the description of models and on the difficulty attributed to some skills that require more abstraction by the Primary group.

This seems to demonstrate that the teachers do not sufficiently value the observation of astronomy phenomena and that they do not always perceive the difficulty of the use of the model and justifications, at least in the case of the daily changes, despite its complication (Baxter, 1989). We understand that the permanent training should focus on the importance of observation, as it is a key aspect which is going to favour the establishment of questions and open the way to the use of explanatory models and to the justification of the facts observed. To achieve this, a recent study (Navarro, 2011), recognising the importance of the observation of the sky, suggested a teaching proposal based on the resolution of problems and it was successfully developed in a Primary classroom. The ideas of the students evolved satisfactorily.

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SCIENCE TEACHERS' ATTITUDES AND PERCEPCTIONS RELATED TO PRACTICAL WORK: A SELF REPORT QUESTIONNAIRE

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Abstract: The purpose of this study was to develop a self-report questionnaire, valid and reliable, to explore teachers' attitudes and perceptions related to practical work. We also aimed to apply the questionnaire to a random sample of secondary teachers and provide data contributing to a characterization of teachers' attitudes and perceptions on practical work. Our motivation to conduct this study comes from the renewed emphasis in enquiry based science teaching and practical work in the most recent curriculum reform for secondary science education. The questionnaire, after trialling, pilot studies and consequent refinement, has proven to be a useful research instrument to identify general and individual tendencies. The initial tendencies identified in teachers' responses suggest good predisposition and benevolent attitudes in general; however these contrast with some teachers, reluctance to practical work, lack of confidence and sense of control. We recognize that our questionnaire is useful to explore teacher thinking but it needs to be complemented with other relevant sources of information like ongoing in-depth interviews to explore the challenges and opportunities of using practical work to develop conceptual understanding and process skills. We see this study as a starting point for further research on effective ways of supporting teachers to develop skills and awareness on the potential and limitations of practical work.

Keywords: secondary science teachers; practical work, teacher attitudes; teacher perceptions, questionnaire development.

INTRODUCTION AND BACKGROUNG

Secondary school science teachers usually have to teach a wide and demanding curriculum. The problem of how to support them in initial and in-service training, and to develop the basic knowledge, strategies and skills that they need as practising teachers is still faced by teacher educators around the world. In Mexico, with the recent introduction of a new secondary science curriculum, enquiry based teaching and aspects of the nature of scientific enquiry have a renewed emphasis in the normative pedagogical discourse and associated materials. Teachers are encouraged to incorporate practical work systematically in their practice as in other countries (Anderson, 2007). This places significant demands on the teaching force, given the fairly modest science background of most Mexican secondary school teachers, and the limited opportunities provided to them to be engaged in practical work and investigative processes during their own education and training.

The role of practical work in science education has been widely discussed (Millar et al., 2002; Berg et al., 2003; Lunetta et al., 2007). In this paper, by 'practical work' we mean any teaching and learning activity that engages teachers and students in observing or manipulating concrete objects and materials (Millar, 2004). This term is used in preference to ‘experimental’ or ‘laboratory work’, in order to include those activities involving observation or manipulation conducted in and out of the school setting. Standing from a situated perspective (Brown, Collins and Duguid, 1989), we are aware that many contextual and social elements are involved in complex human interactions such as teaching. Teachers inevitably develop their own perceptions and attitudes towards practical work; those perceptions, in turn, might interact with curriculum demands. Moreover, such attitudes are likely to be reflected in their discourse and actions and may have influence on the activities they provide for students, how they organise and manage their classroom, what role they adopt, the way they use equipment and materials, and the criteria they use in assessing the success of practical work (Abrahams & Saglam, 2010).

As a way to systematically explore secondary science teachers’ perceptions and attitudes related to practical work, we report here the design and development of a questionnaire. The development of the questionnaire was conducted in the context of a larger project oriented to perform a diagnostic study on the use of practical work in science education in public secondary schools in Nuevo Leon, a state in the North-East region of Mexico. Such project also intends to inform the elaboration of teaching materials based on practical work to support the official curriculum. Consequently, our aims were:

- To develop a self-report questionnaire, valid and reliable, to explore teachers’ attitudes and perceptions related to practical work.
- To apply the questionnaire to a random sample of secondary teachers and provide data contributing to a characterization of teachers´ attitudes and perceptions on practical work.

METHODS AND SAMPLES

This paper focuses on their characterization based on a transversal study. We consider the use of a questionnaire only as a mean to gather information and a resource which outcomes should be complemented with data from other sources (e. g. interviews, field notes, classroom observation).

We initially developed a self-report questionnaire containing Likert scale items grouped in sections to explore four aspects:

Section 1: purposes attributed to practical work (20 items)

Section 2: attitudes towards practical work (20 items)

Section 3: perceptions of engagement and control (21)

Section 4: subjective experience during implementation of practical work (36 items)

The following examples illustrate the nature of the items:

Table 1. Examples of items in each section

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Section 1: Purposes attributed to practical work In science lessons, enquiry and practical activities intend that students...					
	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Learn to use instruments or tools (e. g. a thermometer)					
Collaborate among them and work in groups.					
Section 2: Attitudes towards practical work					
	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
When doing practical activities, students ask things I do not know and make me feel uncomfortable.					
Practical activities work well if I prepared them well.					
Section 3: Perceptions of engagement and control					
	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
I only conduct the practical activities appearing in textbooks because I have no time to look for other ones.					
I have to conduct practical activities in my science classes, although I don´t like them.					
Section 4: Subjective experience When I conduct enquiry and practical activities I feel...					
	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Organized					
Dominant					
Stressed					

In the development and application of the questionnaire we followed these stages:

I. Pilot study: elaboration of items, revision of items by external judges, initial application to a small intentional sample of teachers, items analysis, integration of the refined version of the questionnaire.

II. Final application: To a random extended sample of teachers, items analysis (validity and reliability tests), response analysis, characterization of attitudes and practices related to practical work.

41 teachers were selected intentionally to participate in the pilot study. 102 teachers comprised the sample for the final application. Both groups of participants included female and male teachers aged 23-56, with 2 to 34 years of teaching experience; all were practicing secondary school science teachers working in state secondary schools. The first version of the questionnaire used in the pilot study included 96 items. The final version, after refinement, ended up with 100 items.

In the pilot study data analysis looked for statistical evidence on the discriminative power and internal consistency of the items, which could tell us about the validity and reliability of the questionnaire as a research instrument. For this purpose, t tests and Cronbach’s Alpha coefficients were performed with SPSS v.14. Data coming from the final application was also processed statistically to confirm the validity and reliability of items, but the main analysis intended to identify patterns and tendencies in teachers´ responses.

RESULTS

The analysis of the pilot study data indicated that 84 of the initial 97 items had adequate discrimination power (t test, $p<0.05$); this indicated the need to refine 13 items. Regarding the internal consistency within each section, we obtained high and significant

Cronbach's alpha coefficients ($p<0.05$) for sections 1(purposes) and 2 (attitudes) with all items being correlated and suggesting good internal consistency. For sections 3 (engagement and control) and 4 (subjective experience), coefficients were no significant and it was possible to identify 19 items with no correlation to their sections. Since both statistical tests pointed out problems with mostly the same items, we proceed to review and refine them. Such review resulted in the eventual restructuration of sections 3 and 4. A second version of the questionnaire was trialled again with a sample of 20 teachers. This time we obtained satisfactory t values for each item and significant alpha coefficients for each section. These results gave us confidence in the use of the questionnaire as a research instrument.

In the final application, we ran the statistical tests for confirmatory purposes and found no significantly different results. Teachers tended to attribute as many cognitive as affective purposes to practical work which suggest that, as a group, they conceive that practical work is useful for almost any teaching purpose. Interestingly, they avoided to totally agree or disagree with items stating that practical work was useful to maintain the discipline in the classroom. 69% of teachers (71 out of 102) reported to hold positive attitudes towards the implementation of practical work. They expressed agreement with negative attitudes only in the case of two items related to the possibility that activities may not work or were likely to cause accidents. Although individually teachers differ significantly in their tendencies, an important number of them (79%) tended to perceive themselves engaged and in control when doing practical work. Similarly, in 71% of teachers the tendency was to report the experience of positive subjective experiences when implementing practical work as part of their teaching.

CONCLUSIONS AND IMPLICATIONS

This study was focused on targeted aspects of teacher's attitudes and perceptions related to practical work. It can only provide a characterisation of the main features and tendencies within the sample or at an individual level. This information is useful in building a diagnostic description of how teachers are equipped to face curriculum demands concerning the implementation of practical work and associated aims. We followed the conventional procedure in the design and managed to develop a valid and reliable questionnaire, which is as a self-report instrument that privileges teachers' points of view. In order to make sense of these views, it would be important to explore them in conjunction with knowledge about teachers training background and conditions in schools for practical work. Other relevant aspects to incorporate in our diagnostic study include ongoing in-depth interviews to a subsample of teachers to explore the challenges and opportunities of using practical work to develop conceptual understanding and process skills. A more qualitative approach, like the dilemma discussions adopted by Hye-Gyoung & Mijung (2010) could be fruitful for such purpose.

The questionnaire, after trialling, pilot studies and consequent refinement, has proven to be a useful research instrument to identify general and individual tendencies. The initial tendencies identified in teachers' responses suggest good predisposition and benevolent attitudes in general; however these contrast with some teachers' lack of confidence and sense of control. Despite the sample size in the final application, we are not in the position to generalise the identified tendencies. Our initial characterisation of teachers` attitudes and perceptions will serve as a starting point for further research on effective ways of supporting teachers to develop skills and awareness on the potential and limitations of practical work. Some efforts should be oriented to develop awareness about distinctive teaching purposes and critical teacher interventions when implementing practical work with secondary school students.

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WHAT STRANDS OF RESEARCH IN SECONDARY "NANO-EDUCATION"?

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Abstract: We present a review of literature that gives a snapshot of an emerging field in science education: "nano-education", with a focus on secondary education. Our corpus was maid of 20 articles from science education peer-reviewed journals and conference proceedings. We identified four strands of research: reflections prior to curriculum development on nanosciences and nanotechnologies; studies on students' conceptualisations of nano-related concepts; use of haptic tools to teach nanosciences and nanotechnologies; and professional development for secondary school teachers. We also pointed the lack of research regarding nanosciences and nanotechnologies as a socioscientific issue.

Keywords: Nanotechnologies - Nanosciences - Secondary education - Nanoliteracy - Curriculum development

BACKGROUND, FRAMEWORK AND PURPOSE

Since the launch of the National Nanotechnology Initiative by the US government in 2000, many countries have been investing in nanosciences and nanotechnologies developments. These investments are often accompanied by discourses laying emphasis on the interests to introduce nanosciences and nanotechnologies into the science curriculum (Roco, 2003) and also by funding to develop pedagogical materials as well as educational research on this topic. This is particularly pronounced in the US where the National Science Foundation has made many efforts to introduce nanosciences and nanotechnologies[1] in secondary schools' classrooms and alloted many grants for research on "nano-education". As a result, science education on nanosciences and nanotechnologies has been developing for a few years and this emerging field in science education may undergo important expansion in years to come.

We have worked on reviewing research literature in science education dealing with the introduction of "nanos" in secondary education (Hingant and Albe, 2010). Our purpose here is to give an insight into the directions in which science education research on nanosciences and nanotechnologies has been developing so far and has already produced results.

RATIONALE

Many attempts have already been made to introduce nanosciences and nanotechnologies in secondary education in particular in the US. Accordingly, our aim was to provide an overview of this emerging field by reviewing literature to answer the following questions:

Which orientations of research about the introduction of nanosciences and nanotechnologies in secondary education have started to be explored?

Which results have already been yielded by these studies?

METHODS

The words nanosciences and nanotechnologies refer to a vast collection of scientific and technological research and developments involving nanometric objects. However actors involved in these developments do not agree on what deserve the tag “nano” and what is excluded from nanosciences and nanotechnologies. For our review, we left it to the authors to chose their own definitions of “nanos” and we only used articles whose authors claimed an interest for introducing nanosciences and nanotechnologies in secondary education. Accordingly, we chose the key words “nanoscience(s)”, “nanotechnology(ies)” and “nanoscale” along with “teaching” and “education” when searching articles. We gathered papers using ERIC database and reviewing papers from various English, French and US peer reviewed journals: *Science Education, International Journal of Science Education, Journal of Research in Science Teaching, Aster, Didaskalia, Journal of Science Education and Technology, Research in Science Education, International Journal of Science and Mathematics Education, American Educational Research Journal, Review of Educational Research, Educational Evaluation and Policy Analysis, Review of Research in Education, Journal of Curriculum Studies, Studies in Science Education.* We also visited selected Internet websites that led us to consult different conference proceedings (of the National Association for Research in Science Teaching conference and of the American Society for Engineering Education) as well as the *Journal of Nano Education* created in March 2009. We retained 20 documents, excluding from our corpus papers only depicting an innovation and lacking a sound theoretical framework.

RESULTS

We identified four orientations of research. The first one is related to reflections prior to the design and implementation of a “nano-curriculum”. Studies have also been completed on the conceptualisation of some “nano-related” concepts. Some work deal with the use of some particular learning tools to teach students some nano-related concepts. We also encountered articles that were dealing with secondary school teachers' professional development on nanosciences and nanotechnologies.

Reflections prior to the design and implementation of a “nano-curricula”

Among the questions preceding the design and implementation of nano-lessons we listed the following:

- Why to introduce “nanos” in secondary education and who is targeted?
- How to organise teaching nanosciences and nanotechnologies in secondary education?
- What concepts are considered prominent to understand the heterogeneous objects grouped together by the words nanosciences and nanotechnologies and how can these concepts be integrated in the science curriculum?

We identified two reported goals put forward to advocate the introduction of nanosciences and nanotechnologies in secondary education:

- To recruit the future “nano-workforce”;
- To provide citizens-in-the-making with tools to understand a world pervaded with nanotechnologies.

To introduce nano-contents, Schank, Krajcik, & Yunker, (2007) and Stevens et al., (2009b) emphasise the inherent interdisciplinarity of nanosciences and nanotechnologies. Stevens et al., (2009b) also underline the significance to take into account the existing constraints set by the educational systems. For their part, Schank et al. (2007) go further and consider that nanosciences and nanotechnologies provide an opportunity to profoundly reform the way science is taught in secondary education.

Finally concerning the concepts to be taught and deemed central to understand nanosciences and nanotechnologies, the National Science Foundation funded workshops in 2006 and 2007 gathering educators and scientists to identify “big ideas” of nanosciences and nanotechnologies. This resulted in the identification of nine big ideas and their associated learning goals appropriate for secondary education (Stevens et al., 2009b):

1.Size and Scale
2. Structure of Matter
3. Force and Interactions
4. Quantum Effects
5. Size-Dependent Properties
6. Self-Assembly
7. Tools and Instrumentation
8. Models and Simulations
9. Science, Technology and Society.

Works on conceptualisation of “nano” related concepts

Significant concepts to understand nanosciences have been targeted for example in the book “the big ideas of nanoscale science and engineering” (Stevens et al., 2009b) and empirical works have been completed on the conceptualisation of these notions:

- *on size and scale*: some works tend to show that people and in particular pupils encounter difficulties in apprehending small scales (Tretter, Jones, Andre, Negishi, & Minogue, 2006a; Tretter, Jones, & Minogue, 2006b). Tretter *et al.* (2006b) have also laid emphasis on the significance of direct experiences to conceptualise scales. Other authors have tried to understand how students develop their conceptions of size and scale and plan to use their findings to develop a learning progression on size and scale (Delgado, Stevens, Shin, Yunker,& Krajcik, 2007). They found that students' knowledge ranged from connected to entirely disconnected.

- *on the “nature of matter”*: having identified crucial concepts for the understanding of two constructs, atomic model and electrical forces, Stevens, Delgado, & Krajcik (2009a) have sought to develop two hypothetical learning progressions and striven to enhance the links between them. Their empirical study showed that students often did not perceive connections important to conceptual understanding.

- *on size dependent properties*: in an exploratory study, Taylor & Jones (2009) found there is a correlation between proportional reasoning ability and understanding surface area to volume relationships.

Works on the use of innovative tools to teach nano-related concepts

Innovative learning tools have been used to teach nano-related concepts. In particular, some devices consisting in a haptic[2] interface coupled to an Atomic Force Microscope have been studied. The influence of haptic on learning and motivation has been investigated (Jones et al., 2004; Jones, Andre, Superfine, & Taylor, 2003). Results showed that using such devices has a positive impact on both students learning and engagement (Jones et al., 2004; Jones et al., 2003). In addition, results obtained by Jones et al. (2006) tend to indicate that the more sensitive the haptic tool is, the more efficient it proves in engaging students in activities and in supporting learning.

Studies on teachers’ professional development

If nanosciences and nanotechnologies are to be integrated in the science curriculum, teachers have sooner or later to be in charge of the teaching of these new contents. Consequently some works are taking an interest in secondary teachers' professional development. Some authors have described the hurdles which may dissuade teachers from integrating "nanos" into their lessons: difficulties to take into account interdisciplinarity, reluctance to deal with notions they have not been acquainted with during their initial training and on which they may be at a loss to answer pupils' questions (Schank et al., 2007). However, a few professional developments opportunities on nanosciences and nanotechnologies have already been offered to secondary school teachers and some have been studied in empirical works.

Tomasik et al. (2009) found that the learning environment used for their course met teachers expectancies and that teachers chose to introduce nano-lessons throughout the year or as one bulk unit.

Bryan et al. (2007) noted that teachers came to a nano-summerschool program mainly to learn nano contents and not about inquiry.

Concerning teacher's use of models for teaching nanotechnologies, it has been found that teachers view them as primarily useful for "show and tell" purposes (Bryan et al., 2007; Daly and Bryan, 2007)

Finally, Bryan et al. (2007), Daly et al. (2007), and Hutchinson et al. (2009) reported some difficulties encountered by teachers to implement nanosciences and nanotechnologies contents in their classrooms. Teachers have to locate where it could fit. Bryan et al. (2007), Daly et al. (2007), and Hutchinson et al. (2009) found that "nanos" were often added as extensions to pre-existing lessons. Hutchinson et al (2009) also pointed out that teachers could lack time and confidence and also encounter technical difficulties to teach nano-lessons. Daly et al. (2007) and Hutchinson et al (2009) also underlined that teachers sometimes had difficulties to cope with interdisciplinarity.

CONCLUSIONS AND IMPLICATIONS

Our literature review provided four strands of research: reflections prior to the introduction of nano-lessons in the curriculum; studies on students' conceptualisations of nano-related concepts; use of innovative learning tools to teach nano-related concepts; and professional development for secondary school teachers. Thus, in the articles we vetted, we haven't found any studies regarding nanosciences and nanotechnologies as a socioscientific issue. However these developments raise controversies and among the "big ideas" deemed essential to grasp an understanding of nanoscale science and engineering the item "science, technology and society" was included (Stevens et al., 2009b). Consequently, to us, if nanosciences and nanotechnologies are to be introduced in secondary education so that every student could understand and participate in the debates surrounding these developments, the controversial dimensions of nanotechnologies also have to enter the classrooms.

NOTES

1. In the United States, authors working on the introduction of nanosciences and nanotechnologies in secondary education often use the terminology "nanoscale science and engineering" (e.g.: Stevens, Sutherland, and Krajcik, 2009b).

2. A haptic tool is a tool rendering the sense of touch.

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SOURCES OF SCIENCE TEACHING SELF EFFICACY BELIEFS OF EXPERIENCED HIGH SCHOOL SCIENCE TEACHERS

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Abstract: This ethnographic research aims to search for the sources of self-efficacy beliefs of experienced high school science teachers. Semi-structured formal interviews were made with three experienced science teachers (one biology, one chemistry and one physics teacher) who had experience over nine years of teaching. Results revealed that teachers' problem solving, teachers' making experiments and students' interest during lesson are sources of an increase in experienced science teachers' teaching science self efficacy beliefs. Outer factors related with students and class atmosphere are sources of a decrease in science teachers' teaching science self efficacy beliefs. Science teachers' mastery experiences especially the indirect, perlocutionary mastery experiences which include students' success and interest was found to be most highlighted source of teachers' science teaching self efficacy beliefs. Social/verbal persuasion is reported as a second effective source. Vicarious experiences and psychological and emotional arousal was mentioned by science teachers as not much effective for their teaching self efficacy beliefs. This study suggests that the great effect of mastery experiences on science teachers self efficacy beliefs would be analyzed deeply and might be separated into components and specific teaching activities for science teachers should be analyzed with respect to their effects on science teachers' more static and developed science teaching self efficacy beliefs.

Keywords: science teaching self efficacy beliefs, sources of self efficacy, experienced teachers, high school science.

BACKGROUND, FRAMEWORK, AND PURPOSE

Bandura (1986, p. 391) defined self-efficacy beliefs as "People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances". A teacher's self efficacy belief is so crucial because literature supports its consistent positive relationship with teacher behavior and student outcomes (Gibson & Dembo, 1984). Moreover, Ashton (1984) stated that "…no other teacher characteristic has demonstrated such a consistent relationship to student achievement" (p. 28).

A teacher's sense of efficacy may influence their emotive state, their goal setting and their persistence (Ashton and Webb, 1986). Denham and Michael(1981) found that there is some evidence to suggest that teacher attitudes influence teacher behaviours and that teacher behaviours influence student achievement. Research that is more recent has found that teacher self-efficacy beliefs strongly influence the nature of a teacher's role, planning, and, consequently, curriculum and student learning (Tobin, Tippins, and Gallard 1994). For, example, in science teaching, teachers with high self-efficacies were found to be more likely to use inquiry and student-centered teaching methods, while those with low self-efficacies were more likely to be teacher directed (Czerniak, 1990).

Research on science teachers' self efficacy beliefs is one of the growing trends among teacher education researchers recently. Science teaching efficacy is defined as a teacher's belief about his/her capability to teach science effectively and to affect student achievement

(Riggs, 1988). Science teaching efficacy belief has two dimensions in accordance with the Bandura's two sub-constructs within the conceptualization of self efficacy: personal science teaching efficacy beliefs (PSTE) and science teaching outcome expectancy beliefs (STOE). PSTE refers to a teacher's belief in his/her ability to perform required science teaching behaviors and STOE refers to the teachers' beliefs about the statement of "students can learn science given external factors such as their family background, socioeconomic status (SES), or school conditions" (Riggs, 1988, p. 20). As Bandura asserted, one's self efficacy is task or role specific and it can be changed according to situations. Therefore, teachers' self efficacy is examined under their subject area and its changing is examined for different conditions of teachers, that is, generally for pre-service and in-service conditions.

The usefulness of a high level self efficacy of teachers is obvious. However, the vital question here is "what are the sources of self efficacy?" Bandura (1997) defines four sources of efficacy building information: mastery experiences, vicarious experiences, social/verbal persuasion and psychological and emotional arousal. Determining specifically the sources of teachers' self efficacy in their subject area teaching would be helpful for teacher training or assisting teachers in schools and for developing self efficacy scales for science teachers.

This study aims to answer three main questions revolving around sources of experienced science teachers' self efficacy beliefs. These are:

1. What types of experiences are considered by experienced science teachers as effective for increasing their science teaching self efficacy beliefs?
2. What types of experiences are considered by experienced science teachers as effective for decreasing their science teaching self efficacy beliefs?
3. How are experienced science teachers' self efficacy beliefs linked to Bandura's four sources of self efficacy beliefs?

RATIONALE

Dembo and Gibson (1985) stated that "The problem of identifying antecedents of efficacy and developing ways to enhance teachers' sense of efficacy is critical…researchers must consider many variables as well as the complex manner in which they interact" (p.177). There is a great mount of researches about self efficacy of pre service teachers. Self efficacy of in service teachers is a less searched area than of pre service teachers. In fact, a more developed, and more static self efficacy of experienced teachers is need to be searched in order to understand what pre service teachers are going to face with in their following years and also as Ramey-Gassert, Shroyer and Staver (1996) stated, to understand how to motivate teachers to teach science.

Based on the theoretical implications and literature evidence of positive effects of self efficacy in affecting teacher behavior, this ethnographic research aims to search for the sources of self-efficacy beliefs of experienced high school science teachers. In the literature studies about elementary school science teachers' self efficacy beliefs are dominant and hence studies for high school science teachers' science teaching self efficacy beliefs is a bigger gap today. Determining specifically the sources of high school science teachers' science teaching self efficacy beliefs would be helpful for teacher training and assisting science teachers in high schools and for developing self efficacy scales for high school science teachers.

METHODS

Semi-structured formal interviews were made with three experienced science teachers (one biology, one chemistry and one physics teacher). Three science teachers who were female and had experience over nine years of teaching were chosen purposively. Interviews were recorded by audiotape and transcribed in documents. At the beginning of the interviews, an introduction and basic interview guidelines were presented to the teachers. To provide clearness of the terms “self efficacy” and “teaching self efficacy” for teachers during the interview, the explanation of the terms in Turkish, which are provided by academic studies, were both given the teachers in a written paper and explained by the researcher orally. Also, researcher asked to the teachers whether they understood them. Interviews began after researcher was convinced that teachers grasped the terms. Teachers were told that they were going to be asked a series of questions related with teaching self efficacy.

The questions of the interview are prepared by examining the self efficacy tests in the literature. Some items in the tests are turned into question form. There are three parts in the interview. After getting the general information about teachers in the first part, questions about vocational thoughts were asked in the second part. Then for the final part, questions about “how efficacy is influenced and what influences efficacy” were asked. Two listed item questions were asked. These two questions were developed by taking views and answers of other three experienced teachers to the question of “what makes you feel more efficacious in teaching?” The defined items are listed and asked to interviewees to give points from 1 to 5, to show its impact on that feeling of teaching self efficacy.

Finally, the data were grouped and analyzed with clustering technique (Miles & Huberman, 1984) with respect to answering the two main questions of the research.

RESULTS

Results are presented under headings of the three main questions of the study. But before seeing separate and somewhat different views of the teachers, it would be meaningful to give their some personal characteristics.

Profiles of Teachers

Biology teacher: She was 30 years old. She had 9 full years of teaching experience and a master degree in biology. She had taught in university entrance examination preparation courses for 7 years and then she had been teaching in a private school for two years. She said that she had had a great interest in biology and so chose to be a biology teacher. She defined herself as curious and effortful towards science and hence loved her job; teaching. It is noticeable that biology teacher linked the attitude towards science and loving to teach. She answered as “yes” when interviewer asked her whether she saw herself as a successful teacher and she immediately continued by adding “it isn’t a self conceit, right?” In Turkish culture it is commonly accepted as discreditable for someone to praise herself/himself and this biology teacher was so certain about her goodness in teaching such that she worried to assert this explicitly.

The strengths and weaknesses in teaching profession were asked to teachers. Biology teacher said that due to long time she had spent in university entrance preparation courses she was good at those subjects asked in UEE (university entrance examination) and making students study –in UEE courses students are scheduled to study and solve necessary number of tests about exam subject and they are controlled by teachers periodically. Hence, an important role of teachers in those courses is to make students study and to control their plan, in other words, to help students self regulate studying-. She explained her vocational weaknesses as making experiments, fieldtrips and observation. Moreover she explained that those weaknesses were due to her insufficient experience in school teaching and she added that she needed development in those school activities.

Chemistry teacher: She was 35 years old. She had 14 full years of teaching experience and in last two years of her teaching she was also an administrative staff in her school. She said that the reason of her choice to be a chemistry teacher was that she had loved her chemistry teacher much in high school. She defined herself as “not a very good teacher but a little above the middling good teachers”. When interviewer asked her whether she saw herself as a successful teacher she said “not much, I think”.

Chemistry teacher criticized herself about not spending much time on her professional development and mentioned it as a weakness in her profession. She explained her weakness such that she would have solved much more chemistry problems and would have finished various test books and she would have made experiments alone in laboratory. She mentioned her good lecturing as strength in her teaching profession.

Physics teacher: She was 37 years old and had 16 full years of teaching experience in high schools. She stated her reason of choice to be a physics teacher as her bad physics teacher in high school. The interviewer conceived that this choice was a reaction to interviewee’s suffering in her studentship and hence she had wanted to show a better performance in physics teaching than her bad teacher had shown in the past. She defined herself as a teacher who was trying to have close relationship with her students emotionally and trying to understand them. Moreover she explained the principle of her behavior by saying “in order for students to love the lesson they must first love the teacher”.

When interviewer asked her whether she saw herself as a successful teacher she said that her success depends on classes. In Turkey, in most schools, classes are formed by ability grouping and so meaning of classes in her explanation is success levels of students. She also explained classes’ effect by saying that in good classes her success was better and in bad classes she was trying to help students as much as possible. Physics teacher asserted her deficiencies in classroom management as a weakness and asserted her good subject matter knowledge as strength in her profession.

Increase in science teaching self efficacy beliefs

According to biology teacher solving many problems about subjects increases her science teaching self efficacy beliefs mostly. Chemistry teacher also supported this by exemplifying as skimming and solving problems in different test books. Physics teacher did not say something explicitly about the effect of solving problems on her self efficacy beliefs, however when the instructional activities were asked to put in an order from most to least affective on her teaching self efficacy she put solving problems in the second place.

The other thing that all three science teachers mentioned about its effect on their teaching self efficacy is the interest that students exhibit to the lesson. Biology teacher gave examples of signs that indicate students’ interest for the lesson: students’ listening to lesson carefully, their participation by asking questions and problems that they could not solve, their note taking, their smiling when teacher changes her tone of voice and students’ oral statements about their grasp.

All three teachers supported that making experiments would affect their teaching self efficacy. What is more all of them put *making experiments* on the first place among instructional activities that affect teachers’ science teaching self efficacy. It is worthy that all three science teachers put the instructional activities in the same order with respect to their effects on their science teaching self efficacy. The order was like that: 1. *Making experiments*, 2. *Solving problems*, 3. *Answering questions that students ask*, 4. *Concept Instruction*.

The first research question of the study was that “what types of experiences are considered by experienced science teachers as effective for increasing their science teaching self efficacy beliefs? Results of this study provide an answer for this question like that: teachers’ problem solving, teachers’ making experiments and students’ interest during lesson are sources of an increase in experienced science teachers’ teaching science self efficacy beliefs.

Decrease in science teaching self efficacy beliefs

The reverse of the things that teachers told as increasing their teaching self efficacy is also valid for decreasing it obviously. However, in this section the things that teachers especially mentioned about their negative effect on their teaching self efficacy beliefs are written.

The things that would affect teaching self efficacy negatively for biology teacher were getting a poor score from the examination for teachers –in the private school she worked there were teacher exams for all branches each year-, not getting feedback from students during instruction, not solving more tests and problems and a consensus occurred in the class about not understanding the subject. For chemistry teacher the naughty students who did not progress positively after help, not spending enough time on her professional development-by making experiments in the laboratory- were the things that would increase her teaching self efficacy. According to physics teacher students’ being uninterested, unwilling and not having enough previous knowledge for the subjects would increase her teaching self efficacy beliefs.

The second research question of the study was that “what types of experiences are considered by experienced science teachers as effective for decreasing their science teaching self efficacy beliefs?” The gathered answer for this question from the study is that a consensus occurred in the class about not understanding the subject, uninterested and unwilling students, students not having enough previous knowledge for learning new subjects, problematic students who did not progress after help and bad class atmosphere are sources of a decrease in science teachers’ teaching science self efficacy beliefs.

Links to Bandura’s four sources of self efficacy beliefs

The third and last research question of the study was that “how are experienced science teachers’ self efficacy beliefs linked to Bandura’s four sources of self efficacy beliefs?” Gathered results are summarized according to their links to four sources of self efficacy (mastery experiences, vicarious experiences, social/verbal persuasion and psychological and emotional arousal) that are defined by Bandura (1997).

Mastery experiences are mentioned to be most effective by science teachers for their self efficacy beliefs, and this is consistent with what Bandura asserted about effect of mastery experiences on self efficacy beliefs (1997). Getting a high score in teachers’ examination, solving problems and making experiments are mastery experiences that teachers explained that they affect their teaching self efficacy beliefs. However teachers gave more explanations about the effect of students’ achievement, interest and participation to the lesson on their teaching self efficacy beliefs. Moreover, although it is obvious that mastery experience of teaching the subject for years is one of the major source of teaching self efficacy of teachers however, it is not mentioned by teachers in this study maybe due to they are all experienced teachers and do not have concerns about their enduring teaching skills.

Teachers especially mentioned that verbal persuasions are not much affective whereas social persuasions such as students' consensus on teacher effectiveness will be very effective on their teaching self efficacy beliefs. According to teachers, students' empty compliments will not be affective but their sincere views and statements about learning by instruction of teacher will be affective. Verbal persuasions of administrative staff and other teachers are mentioned as weakly affective for their teaching self efficacy beliefs.

The least affective source of teaching self efficacy beliefs for science teachers was vicarious experiences. All three teachers asserted that they seldom compare their selves with other teachers. According to chemistry teacher and physics teacher this would happen only when they see or hear that other teachers use a new instructional tool or strategy effectively. In that case, teachers indicated that they would try to learn and apply the new thing that other teachers do. Biology teacher said that enthusiasm of another teacher might affect her teaching performance positively.

Psychological and emotional arousal does not seem to be affective for science teachers self efficacy beliefs. Only physics teacher said that sometimes negative events she faced in her daily personal life would decrease her teaching self efficacy beliefs. But, she highlighted that she was trying to eliminate the positive effects of those personal life events and succeeded at that at ninety percent.

Other source of teaching self efficacy beliefs of science teachers would be outer conditions which are generally temporary and under not control of teachers. For example, physics teacher and chemistry indicated that students' previous knowledge that are necessary for learning new subject is very important for themselves to feel their selves efficacious on teaching this new subject. Physics teacher also pointed out that class atmosphere is very important, that is when class' academic level is high she feels herself more successful or vice versa. Biology teacher talked about class atmosphere too. Lastly all three science teachers mentioned about the difficulty of the subject matter as affective on their teaching self efficacy. Some topics in their branches are more difficult than others and they feel less efficacious on teaching these difficult topics due to concerns about students' understanding.

CONCLUSIONS AND IMPLICATIONS

Mastery experiences were mentioned to be most effective by science teachers for their self efficacy beliefs however; mastery experiences might be separated as personal and perlocutionary mastery experiences for teachers. Perlocutionary means "an act of speaking or writing which has an action as its aim but which in itself does not effect or constitute the action, for example persuading or convincing" (seslisozluk). Getting a high score in teachers' examination, solving problems and making experiments are teachers' personal mastery experiences that affect their teaching self efficacy beliefs. On the other hand students' achievement, their interest and participation to the lesson are teachers' perlocutionary mastery experiences that affect their teaching self efficacy beliefs. In fact perlocutionary mastery experiences of teachers might be more important for teachers self efficacy beliefs than their personal mastery experiences since three teachers in that study gave fifty percent and above weight for their effect on students' success when it was asked. Students' reactions and success are important indicators of teachers' teaching success, i.e. mastery experiences.

Social/verbal persuasion effect on teaching self efficacy of science teachers can be divided as social persuasion and verbal persuasion because teachers especially mentioned that verbal persuasions were not much effective whereas social persuasions such as students' consensus on teacher effectiveness would be very effective on their teaching self efficacy beliefs.

In brief, the great effect of mastery experiences -both revealed in the results of this study and in the literature- on science teachers self efficacy beliefs would be analyzed deeply and might be separated into components such as personal mastery and perlocutionary mastery experiences and specific teaching activities for science teachers should be analyzed with respect to their probable and plausible effects on science teachers' more static and developed science teaching self efficacy beliefs.

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THE COMPLEX ROAD TO MATHEMATIZATION IN PHYSICS INSTRUCTION

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Abstract: How to facilitate students' understanding of science's abstract concepts is definitely a major concern of every dedicated physics teacher. However, discussions about promising ways to be successful at this task are not always part of teacher training curricula. With the goal of contributing to the research in this field, we have analysed a set of lectures given by a distinguished physics professor. In this proposal we present the analysis of two lectures where the abstract concepts of charge density and electric flux are taught. The complexity of the mathematization of these concepts is evident both by the considerable amount of time dedicated to it and by the different strategies used by the professor in his exposition. These strategies are described and exemplified. Using the software *videograph* for the video analysis, we were able to identify the specific instants where each strategy takes place as well as their duration and interplay. This dynamical process is visualised with the aid of a timeline generated by the program. In general, our analysis evidenced that the professor adopted a "concrete to abstract" approach, made an extensive use of visual representations and concrete analogies, mentioned idealizations explicitly and made punctual metacognitive remarks. Taking into account the future perspectives of our research, the categorization of the didactical strategies used by this professor shall allows us to develop comparative studies with other lectures on the same topic. Moreover, the derivation promising strategies to teach the structural role of mathematics in teacher training courses is also aimed at by this research.

Keywords: Mathematics in physics instruction, video analysis, mathematization complexity, structural skills.

INTRODUCTION

Physics and mathematics are deeply interrelated since the very origin of scientific knowledge and this mutual influence has played an essential role on both their developments (Bochner, 1981; Gingras, 2001, amongst many others). Mathematical concepts being motivated by physical problems can be found, for instance, at the origin of calculus and its relation to the study of movement or at the development of vector analysis and the need for a mathematization of electromagnetic phenomena. From the physics perspective, mathematical concepts created in an "abstract world" are commonly "applied" by physicists to build their theoretical explanations. The use of conic sections in Kepler's astronomy or of complex numbers in Fresnel's optics are some among many other examples. More recently, this mutual interplay has reached a higher level where the very physical concepts "cannot be divided into a mathematical part and a non-mathematical one" (Boniolo & Budinich, 2005, p. 86).

But what are the implications of this successful relationship for physics education? Despite the significant amount of research on how to improve students' conceptual understanding of physics, works focusing on building a meaningful comprehension of the role of mathematics in physics education are considerably less common. Hestenes (2003, p. 104) raises attention to this fact when he states that "the challenge is to seriously consider the design and use of mathematics as an important subject for physics education research".

A quite widespread view regarding this theme is that mathematical skills are prerequisites for learning physics. However, it seems that the domain of these skills is far from being a guarantee of success (Hudson & McIntire, 1977). Previous research about students' use of mathematics to solve physics problems (Tuminaro & Redish, 2007) has already shown that rote application of formulas without physical reasoning is a rather common strategy. It has also been demonstrated that students face a huge difficulty when they need to transfer knowledge between mathematics and physics (Basson, 2002). It is fairly reasonable to expect that this difficulty is related to instruction methods, but works approaching this field from a teaching perspective are even less frequent.

With the goal of contributing to close this gap, our research is concentrated on the analysis of mathematical reasoning in physics lectures. The ability to use mathematics in physics is divided between *technical skills* - the ones related to the domain of basic rules of mathematics and normally developed in math's classes - and *structural skills* - which are related to the capacity of recognizing the structural role of mathematics in physical thought [1]. Among the latter, the extreme complexity of *mathematization* - translation between the physical world and mathematics - and the main role it played in the lectures from our data demanded a deeper analysis. Even though fostering students' understanding of science's abstract concepts is a major concern of every dedicated physics teacher, promising ways to be successful at this task are not always available. Therefore, in this work we address the following questions: Which strategies are used by an experienced professor to teach the mathematization of the physical concepts of charge density and electric flux? How does the interplay between these strategies take place during the lectures?

METHODS

Aiming at a deeper investigation of the mathematical reasoning in physics instruction, we decided to conduct a case-study at university level. We chose to analyze the lectures of a particular professor from the University of São Paulo for he is widely acknowledged as an excellent lecturer, since he constantly encourages his students to reason about the physical meaning of the mathematical formalism. In this sense, we started from the hypothesis that his approach would focus on the structural role of mathematics instead of its technical aspect.

Our data consist of the recordings of 40 lectures (total of approximately 60 hours of video) from a course on Electromagnetism. Initially, we watched the lectures directing our attention to the moments where mathematical reasoning took part in the exposition. More specifically, we concentrated both on the explanation of fundamental concepts that are expressed mathematically (e.g. each one of Maxwell's equations) and on problem solving moments.

Afterwards, we chose some lectures for deeper analysis with respect to the identified *structural skills.* For video analysis we used the software *videograph*, divided the lectures in 20-second intervals and categorized each of them. In this work, we present the analysis of two lectures in which the structural skill *mathematizing* plays the central role. The content is the introduction of the rather abstract concepts of charge density and electric flux. The complexity of this process is highlighted by the description of different strategies used by the professor and by the image of a timeline where their frequency and interplay can be evidenced.

RESULTS

The following table presents the set of categories that appear more often in the analysis of the two lectures presented in this work. The main goal of both lectures is to *mathematize* the concepts of charge density and electric flux.

Category	Description	Examples from the lectures
Mathematizing M3 Just/Comp. M2 Math Struct. M1 Modeling	The process of mathematization occurs in a gradual way. Initially, the professor makes an extensive use of concrete representations and clarifies the idealizations imposed by the theoretical model. Then, mathematical structures are used to represent physical quantities and their relations. Normally, justifications for the use of certain structures and comparisons between different mathematical representations are presented and discussed.	*"This page is not bi-dimensional, but I think of it as if it were" M1* *"We normally use Cartesian or polar coordinates to think about the two-dimensional situations" M2* *"We use polar coordinates because the situation is symmetric" M3*
Visual representations V2 Pictorial V1 Gestural	Along the process of constructing mathematical representations of the physical concepts of charge density and electric flux, the professor makes use of several visual representations. More specifically, many drawings are made and his language is extremely gestural.	*"This is theta* (points at the door) *this is theta plus d theta* (opens the door)*" V1*
Analogy A2 Formal A1 Material	Analogical reasoning is extensively used during the lectures. Everyday life examples and material analogies with other physical phenomena have a powerful role in the construction of the physical concepts of charge density and electric flux. Moreover, catching attention to formal similarities is also a common strategy.	*"How can we describe the population density of our country?" A1* *"They took this mathematical formulation to use in many other cases [...] But there are important differences" A2*
Metacognition	Metacognition is the knowledge and awareness of one's own cognitive processes and the ability to monitor, regulate and evaluate one's thinking. The professor frequently encourages his students to think about their own thinking during the lectures.	*"His question is very good. It indicates confusion, but this always occurs with everyone who studies this thing. If it did not occur with you, it's because you didn't realize it yet"*

Table 1: Description of the most common strategies used by the professor to mathematize the physical concepts of charge density and electric flux with examples from the two analysed lectures.

Charge density lecture

The following timeline (Fig. 1) - created with the software *videograph* - is a visual representation of a lecture on charge density. It provides an insight to the dynamics of the explanation process that took place during the lecture.

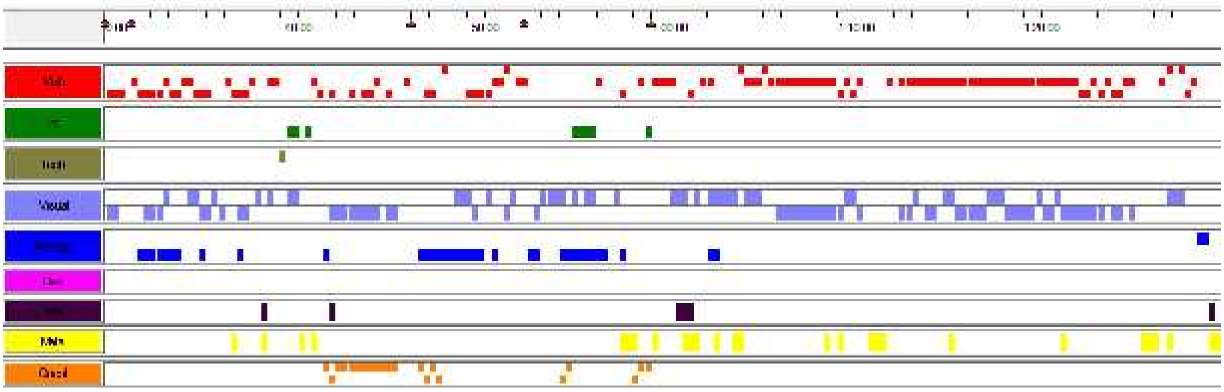

Figure 1: Timeline containing 60 minutes of the charge density lecture. Description of the categories from bottom to top: Quest - Dialogues between the professor and the students; Meta - Metacognitive remarks. Phi - Philosophical comments; Ded - Mention to deductive aspects; Analogy - Everyday life examples, material analogies with other physical concepts and formal similarities between different physical phenomena; Visual representations – gestural and pictorial; Tech - technical manipulations; Int - Interpreting mathematical expressions physically; Math - Translation between the physical world and mathematics.

This timeline allows us to identify the importance of each strategy used by the professor as well as the time dedicated to them. It is clear that visual representations (light blue) play an important role to make the abstract idea of charge density more intelligible. An intensive use of gestures is detected, for example, when the professor explains three different coordinate systems to describe volumetric charge density with the aid of a box and the classroom door. Several pictorial representations, as well as concrete analogies (dark blue), are employed as sources of explanation for the introduction of each different case of charge density (linear, surface and volume).

It is also possible to notice that the idealization process and the use of mathematical structures are highly important due to the time dedicated to them (red). By watching the lecture, one realizes that the professor makes an effort to mention them explicitly. The frequent shift from concrete representations to idealizations is also noticeable and metacognitive remarks (yellow) are frequent along the whole lecture. In the end, a longer moment of justification takes place as if the reasons why the students should learn the mathematical description of charge density are being summarized.

The following transcripts from the professor's discourse and their corresponding categorization complement the described analysis:

32:00	Imagine that you are all point charges and I want to calculate the net field at the position where I am. (A1, V1)
1:00:20	This (reference of frame) is a reasoning instrument, it is not in nature, but in your mind. It is an invention. (Met, Phi)
1:09:20	That is actually not a square, but if everything is very small, then it is useful to make this approximation. (M1, V2)
1:29:00	Today we learned some strategies to deal with distributions of things. This is very general, it can be with charge, mass, population, anything that needs to be distributed. Cosmology, stars, galaxies, Parsec, all [...] This makes sense and this is the way we think. (A2, Met)

Electric flux lecture

In the analysis of the electric flux lecture, we notice a similar pattern, which is illustrated by the timeline presented at figure 2.

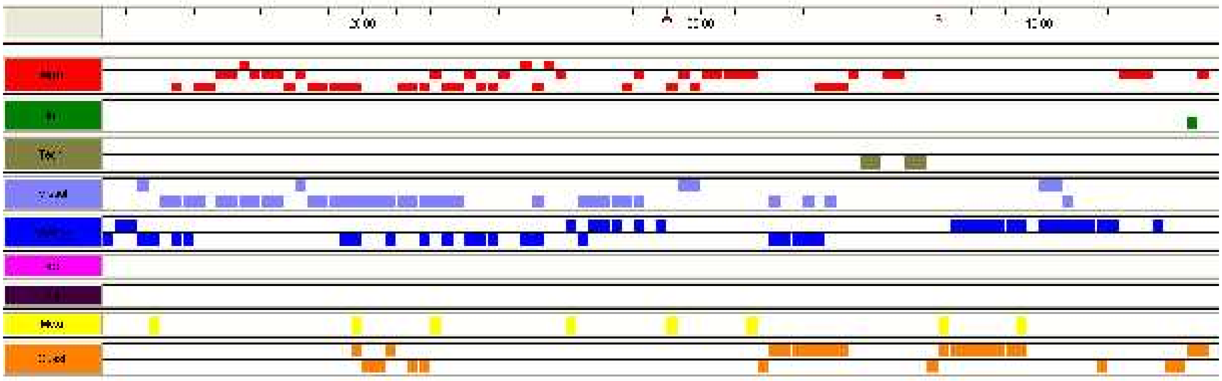

Figure 2: Timeline containing 32 minutes of the electric flux lecture.

The professor starts this lecture with different physical phenomena where the notion of flux applies, mentioning everyday life examples and using several analogies. Then, each relevant variable that influences this magnitude is mentioned and discussed with the students. Once again, we notice that visual representations (especially gestures) are extremely useful for the explanation of the concept.

Instead of just giving the mathematical formula of the flux of a vector field through a surface, the professor presents its mathematical structures (dot product and surface integral) as reasonable for the description of the flux concept. Moreover, although many different phenomena are mentioned, explicit remarks about important differences between them (e.g. the electric and gravitational flux have no velocity) are explicitly stated.

The following transcripts from the professor's discourse and their corresponding categorization complement the described analysis:

18:20	We speak about flux through a surface. […] If the direction of the normal to the surface varies, the flux also changes. (M1, V1)
26:00	Then we define flux by the surface integral of the projection, scalar product, between the vector I'm considering and the normal to the surface. (M2)
37:20	His question is very good. It indicates a confusion, but this always occurs with everyone who study this thing. If it did not occur with you, it's because you didn't realize it yet. It is occurring and you are not aware of that. (Met)
39:40	Every time you work in hydrodynamics – bees, water air – the flux represents something that passes through a surface. They took this mathematical formulation to use in many other cases […] But there are important differences. The gravitational field doesn't really flow, it doesn't have any velocity. It is there. (A2)

CONCLUSIONS AND PERSPECTIVES

When a physics teacher simply states the formula that describes a particular physical phenomenon and then uses it to solve standard problems he/she is actually making an enormous conceptual jump. In reality, he/she is usually underestimating the complex process of mathematization. A brief overview of the history of physics is sufficient to illustrate that the mathematization of this science was a long and complicated process (Bochner, 1981).

In this paper we aimed at stressing the complexity of the translation between the physical world and mathematics by analysing physics lectures on the concepts of charge density and electric flux given by a special professor. The central role of mathematization became evident due to the considerable amount of time dedicated to it. Essentially, this analysis evidenced the following strategies: a *from concrete to abstract* approach, an extensive use of visual representations and material analogies, explicit remarks on idealizations and metacognitive comments. It is not our intention to suggest that this should be followed as a "*how to*" guide, however we strongly believe that these results underline several obstacles of the complex road to mathematization, which should be taken into account in physics lessons.

As future perspectives of this research we intend to investigate other lectures - from this professor as well as from others - and compare their different patterns with the same analytical tool. An additional possibility is to investigate how similar themes are presented in didactical classics like Feynman lectures. With this work we envisage to derive promising strategies to teach the structural role of mathematics with the goal of including such discussions in physics teacher training courses.

NOTES

1. For a deeper discussion about this distinction see Uhden, Karam, Pietrocola and Pospiech (2011).

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ELEMENTARY TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE AND STUDENT ACHIEVEMENT IN SCIENCE EDUCATION

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Abstract: The scope of this paper is to explore whether elementary science teachers' pedagogical content knowledge (PCK) in the content area "states of matter and changes of state" contributes to gains in elementary students' understanding of related concepts. The paper reports on a value-added study with a sample of 60 fourth-grade classrooms and their science teachers. The data derived from a project funded by the German Research Foundation (project "PLUS"). Teachers' PCK and student achievement concerning the mentioned scientific topic were directly assessed with tests. Multilevel regression analyses were conducted to analyze the significance of teachers' PCK for students' progress in elementary science classrooms. Results showed that teachers' PCK was significantly related to student achievement in elementary science after controlling for key student- and teacher-level covariates.

Keywords: teachers, pedagogical content knowledge, student outcomes, science education, hierarchical modeling

INTRODUCTION

In the research literature on teaching and teacher education, there is a shared understanding that teachers' professional knowledge is an important determinant of instructional quality that impacts students' achievement gains (Baumert & Kunter, 2006; Bromme, 1997; Munby, Russell, & Martin, 2001). Yet few empirical studies have assessed the different components of teachers' knowledge directly and separately to predict instructional quality or student outcome. The main goal of this study was to explore whether teachers' pedagogical content knowledge as a crucial component of teachers' professional knowledge makes a contribution to explaining differences in students' learning outcomes in elementary science education.

The study is part of the project PLUS (Teachers' professional knowledge, science teaching and student outcomes in the transition from primary to secondary school) that investigates conditions and outcomes of science instruction in the transition from elementary to secondary education. It was conducted in Germany from 2007 to 2010. The study, which had two measurement points, surveyed a sample of 60 elementary science classes and 54 secondary science classes and their teachers. Drawing on the elementary sample, the study at hand explored whether teachers' pedagogical content knowledge in science contributes to gains in students' understanding of scientific concepts. In order to address this question we used a newly constructed knowledge test to assess teachers' pedagogical content knowledge in the domain of science directly. Teacher data was then linked to data on student outcome, in order to determine the implications of pedagogical content knowledge for student learning.

RATIONALE

The theoretical foundation of research on teachers' professional knowledge was laid at the American Educational Research Association meeting in 1985, when Lee Shulman proposed a model for conceptualizing knowledge for teaching. There he introduced the constructs of generic pedagogical knowledge, content knowledge and pedagogical content knowledge as the core components of the specialized knowledge that is required for teaching. Although researchers have added to or specified these domains of teacher knowledge over the last decades, these three components have consistently appeared in literature and thus seem to be internationally agreed upon as core components of teachers' professional knowledge (Baumert & Kunter, 2006; Borko & Putnam, 1996; Bromme, 1997; Munby, Russell, & Martin, 2001). Knowledge of generic pedagogy (PK) is described as general, subject-independent knowledge about classroom organization and management, general knowledge of learning theory and general methods of teaching. Content knowledge (CK) includes the knowledge of a subject or discipline per se and is not unique to teaching. It goes beyond the knowledge of facts, concepts, principles and theories to also include an understanding of how concepts and principles of a subject are organized and the rules of evidence and proof that are used to justify claims in a certain subject or discipline. Within this classification of teachers' knowledge, pedagogical content knowledge (PCK) is considered the central component of teachers' professional knowledge that distinguishes teachers from subject matter specialists (Grossman, 1990; Shulman, 1987; Van Driel, Verloop, & De Vos, 1998). PCK is defined as a kind of "amalgam" of content knowledge with pedagogical and psychological knowledge as well as with the teachers' personal experiences, creating an understanding of how certain topics, problems or issues ought to be presented and adapted to the learners' different interests and abilities (Shulman, 1987). Magnusson, Krajcik and Borko (1999) proposed a model of PCK in the area of science education, defining five components. They include 'orientations towards science teaching', 'knowledge of science curricula', 'knowledge of students' understanding of science', 'knowledge of instructional strategies' and 'knowledge of assessment for science'. Recent studies on the different domains of PCK (e.g. orientations towards teaching, knowledge of students' understanding or instructional strategies) in mathematics found that teachers' mathematical PCK was positively related to students' gains in mathematical achievement (e.g. Staub & Stern, 2002; Hill, Rowan, & Ball, 2005, Baumert et al., 2010). Whereas studies in the domain of orientations towards teaching have already been established in the field of elementary science (Kleickmann, 2008), studies targeting at the further components of PCK are missing completely in elementary science. Thus, this study aims at measuring elementary science teachers' PCK directly, followed by examining its relevance for students' gains in conceptual understanding.

METHODS

Comprising 1326 fourth-graders (621 girls and 702 boys, 3 students did not indicate gender) in 60 classrooms, the data presented here stems from a project investigating the development and interplay of science instruction, classroom climate and students' science interest in the transition from primary to secondary education in Germany (PLUS Study). The cross-sectional study had a quasi-experimental design. Participating teachers were instructed to provide their classes with a series of three 90-minute lessons on the topic of evaporation and condensation. Students were tested for science achievement concerning the topic "states of matter and changes of state" both before and after the series of lessons. Teacher data were gathered from various instruments amongst others a test assessing their PCK in the domain of "states of matter".

The assessment of teachers' PCK was based on the Magnusson et al. model (1999). Considering the recent studies in mathematics that described 'knowledge of students' understanding' (KSU) and 'knowledge of instructional strategies' (KIS) as components of PCK that trigger students' achievement, the focus of the test was nested within these two components. The developed items asked teachers e.g. to list as many alternative students' conceptions as possible concerning an every-day evaporation situation (KSU). Other items presented situations in which teachers are asked to detect comprehension difficulties or to describe adequate behavior to promote insightful student learning (KIS). The final test consisted of 14 items (11 free-response-, 3 multiple-choice-items) and showed good psychometrical qualities (average ICC= .92, range: .8 - 1.0; Cronbachs $\alpha = 0.69$).

Student achievement was assessed at the end of the unit by a test covering condensation and evaporation as well as the liquid and gaseous state of matter (using water as example). The reliability of the full test (24 items in m*ultiple-choice*- or m*ultiple-select*-format) was Cronbachs $\alpha = .67$ in the pretest and Cronbachs $\alpha = .79$ in the posttest.

Multilevel analyses were used to analyze the impact of elementary science teachers‘ PCK on students‘ gains in conceptual understanding. A two-level model predicting the achievement on the posttest-score on the individual-level by teachers topic-specific PCK on the class level was specified. To account for other important predictors, we controlled for relevant student characteristic like prior knowledge, general cognitive abilities, German as native language, socio-economic background and gender as well as for critical classroom and teacher characteristics like duration of instruction, classroom-management and job experience. To account for missing data we used the full information maximum likelihood algorithm implemented in the software Mplus, which estimates the missing values (Muthén & Muthén, 1998-2009).

RESULTS

In a first step, the variance in students' achievement was decomposed into within- and between-class components. The results showed that 78.6% of the variation in achievement was within classes and that 21.4% was between classes. After controlling for the variables at the individual level, 14.4% of the variation in achievement remained between classes.

In a second step, we specified the individual model. We estimated a random intercept model with the five control variables named above. The most important predictor was that of students' topic-specific prior knowledge at the beginning of the unit, followed by general cognitive ability. Beyond that, German as native language, socio-economic background and gender proved to be less important.

In the next step, the control variables at the class level were entered in the model. The predictors at class level were: duration of instruction, quality of classroom-management and job experience. All variables proved to be significant predictors of students' learning achievement concerning "states of matter" at the end of the unit.

When PCK of elementary science teachers was entered in the model next to the control variables the results revealed a substantial positive effect of the measured PCK on students' gains in science achievement in the domain of “states of matter”. Thirteen percent of the variance in achievement between classes was explained by PCK after controlling for key student- and teacher-level covariates (for detailed analyses see Lange, Kleickmann, Tröbst, & Möller, in print).

DISCUSSION AND CONCLUSION

In the presented study we constructed and implemented a test to assess primary teachers’ PCK directly. In sum first analyses indicate that we succeeded in developing a reliable and valid test which was needed to answer our research questions on the impact of PCK on students’ achievement gains in elementary science classrooms. When controlling for several predictors at individual and class level, we were able to show that elementary science teachers’ PCK positively predicts students’ gains in science achievement in the domain of “states of matter”. These results are nicely in line with findings on effects of domain-specific knowledge in the field of mathematics (Baumert et al., 2010, Hill et al., 2005).

Compared to the effect sizes found in the studies in the domain of mathematics the effect sizes are rather small. It could be argued that this is a domain-specific effect. On the other hand the small effect size could be explained by the short treatment-duration of the study conducted. While the studies in the field of mathematics investigated the impact of teachers’ PCK on students’ learning gains over a whole school year, our study chose a topic-specific approach. Focusing on just one content area, we investigated the impact of teachers’ PCK on student achievement over an average treatment duration of approx. seven lessons. Against this background, the question whether the small effect size is a domain-specific effect or not, is not answered yet. Neither is the question whether we can find an impact of PCK on students’ achievement gains in other content domains within elementary science education. Further research in different science domains and studies over a longer period of time are needed to answer these questions. If these future research attempts confirmed our findings, one could tentatively conclude that it might be possible to improve students’ learning gains in science by improving teachers PCK. One of the next challenges for teacher research would then be to determine how pre-service and in-service teachers can best be supported in acquiring this knowledge.

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SCHOOL CHANGE, TEACHER EDUCATION AND THE ROLE OF MENTORING

- A GERMAN APPROACH IN THE EUROPEAN PROJECT GIMMS –

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Abstract: Schools are experiencing a rapid change of educational practice with an increased demand of professionalism of teachers and teacher educators. Collaborative reflection and discourse in mentoring for teacher education are a basis on which change can occur. In the European GIMMS project (Gender, Innovation and Mentoring in Mathematics and Science) collaborative models of mentoring in science teacher education were studied. The German case study was used as an example of reform in teacher education allowing professional autonomy and critical feedback of teachers in a collaborative model. Beginning teachers accepted the partnership model of mentoring but only within limits concerning cooperation beyond the beginning teacher-mentor relationship. As a reason regularly changing partnerships were noted with unclear requirements of mentors and teacher educators. The many contacts of the beginning teachers do not in advance challenge an innovative mode of reflective teacher education. However mentors seem to operate predominantly with a reflexive mentoring model.

Keywords: mentoring, innovation, collaboration, teacher education, science.

SCIENCE EDUCATION IN TRANSITION

Schools not only in Germany but all over Europe are experiencing a rapid change of educational practice in accordance with reform requirements and demands. In order to guide these innovative processes modern solutions in teacher education need to be traced. In educational reform increased professionalism of teachers and teacher educators is of high importance: "What teachers know and can do is crucial to what students learn" (Darling-Hammond, 2000). Programs for professional development, teaching standards or advisory systems in teacher education comprise approaches to change in schools. But what kind of skills and knowledge base are needed for the teaching profession and what kind of support in the process of change?

In science education we see an emphasis on formal reasoning: systematic and disciplined approaches to the teaching of higher order thinking skills (Olson, 2002). Attempts to integrate ideas from outside the sciences or a discourse across or beyond boundaries of science subjects tend to be resisted in traditional practice. But it is not only subject matter knowledge or academic training that account for good teaching. Collaboration among stakeholders and its transformative power of curriculum change is seen as an important element of innovation. This requires professional autonomy and support for discourse between equals of different professional knowledge in school practice. Collaborative reflection and discourse in a network of practitioners and stakeholders is the basis on which change can occur.

A discourse across subjects, in which the value of practice is discussed, not only entails thinking about reorganising subject matter, but finding ways to justify those values for the socialization of learners as citizens and the perpetuation of a society's cultural norms and values. How to achieve this kind of discourse in school systems?

Mentoring in teacher education is seen as chance to generate reflective collaboration leading to innovative processes. Cochran-Smith and Paris (1995) argue that alternative visions of mentoring beyond traditional transmission models are needed to support teachers in collaborative mentoring and reflective practice. There are different perspectives of mentoring represented in models such as described by Maynard & Furlong (1995). They distinguish the apprenticeship, the competency and the reflective model. In our case the *reflective model* is of special interest for innovation in educational. It reflects a partnership based collaboration of initial and in-career teachers and mentors within a community of learners at school, exploring practical experiences in class in a flat hierarchy. However, this process of teacher engagement is not easily achieved. Usually the system of teacher supervision does not allow professional autonomy and collaboration of teachers. The function of teacher supervision is part of a system assessing success in system-wide achievement standards. Such management of teachers does not foster constructive engagement in change. But how can teachers become actors in curriculum reform?

INNOVATION AND COLLABORATIVE MENTORING IN THE GIMMS PROJECT

The European project GIMMS (Gender, Innovation and Mentoring in Mathematics and Science, Mooney & Lang, in preparation) was undertaken against the backdrop of PISA 2003 to 2009 (Klieme et al., 2010) and the teacher policy study "Teachers Matter" (OECD, 2005).

Trends in PISA for each country over the years indicate changes in time possibly due to changes in the educational systems. The OECD (Klieme et al., 2010) interprets this finding that PISA results over a period of years show whether school systems are becoming successful or not in helping students attain an understanding of life in modern society. Concerning gender results, in mathematics boys outperform girls and in science boys and girls perform about the same. The reasons due for these results are manifold. PISA analyzed some of them such as changes in resources, opportunities to learn, standards, achievement assessment or social climate. The quality of teaching was not controlled but seen as a central challenge of the school systems:"There is a lot of evidence, that the professional development of teachers is an outstanding resource for the quality development of the educational system". (Klieme et al, 2010, p. 296; translated from German). These PISA comparative achievement scores and the insight about the importance of teacher professional development were a starting point for curriculum innovation and inclusion work of the GIMMS project.

In the GIMMS project, coordinated by the University of Limerick, collaborative models of mentoring were used to introduce and study innovation in science teacher education. Seven case studies from Ireland, Spain, Germany, Czech Republic, Denmark and Austria demonstrate a big diversity of presuppositions in educational systems and project assumptions and expectations about innovation and teacher education.

Collaboration in the project was mostly realized in small scale mentor-mentee dyads, but also in occasional collaborative groupings of mentors, experienced teachers, teacher educators and groups of mentees. This will be a challenge for schools to support a regular setting for collaborative exchange.

The theoretical framework of this study is curriculum as political text with deliberative discourse for innovation (Aronowitz and Giroux 1991) inside a web of democratic mentoring relationships of learning with colleagues and teacher educators. This implies border crossing of diverse cultures that in a curriculum process of innovation and change. This argument positioned the work of curriculum innovation in each national system or part of it as a cultural field of discourse with diverse voices (Giroux & McLaren 1986). Voice develops through a physical and intellectual journey beyond boundaries of classroom, of disciples, of culture, of home and school learning. This means that curriculum innovation is justified by shared meaning making with a diversity of voices or stakeholders from a variety of communities in open 'public spaces' and not by top down decisions such as national curricula, prescribed standards or unreflected expert statements.

Elaborating research questions about innovation and mentoring

The GIMMS project has one of its focuses on differences and similarities of mentoring in the participating European countries and will use these insights to develop and pilot mentoring relationships between initial and in-career teachers in physics, chemistry, biology, and mathematics. Hence one of the key research questions to drive the project was: How can we develop better partnerships between initial and in-career teachers for continuing professional development and innovation?

Structure and methods of the GIMMS case study

In the GIMMS project national coordinators delivered national and progress reports during a period of three years and participated in interviews. In a final interview they were asked core questions about their national policy with regard to science and mathematics education and innovation, pedagogical practices and changes and models of mentoring. Some of these questions may get us closer to a better understanding of innovative processes and the role of teachers. Outcomes from this will not be offered here in detail but be used as a basis for further analysis of the national case study in Germany as an example.

In all the national cases innovation was judged to be central and during the three years' time of the project realized successfully. Interactions established a stable structure for exchange, generation of new ideas and innovation. The cooperation with teachers triggered discussions about different ways of teaching and mentoring as innovation within different curricular frameworks. This would not have happened in isolated school or university cultures.

INNOVATION AND MENTORING: THE GERMAN CASE STUDY AS AN EXAMPLE

In spite of all the national differences in background and dynamic of innovation in teaching and teacher education there is one consistent driving factor in every of the cases: the interaction of engaged teachers with a university or research and development institution. This answers the question, how teachers become actors in curriculum reform: As actors they need collaborative partnerships to cross boundaries of narrowed school practice.

In the *German* case study student teachers agreed that the intended reform in teacher education allowed professional autonomy and critical feedback of teachers with regularly changing partnerships but this produces some confusion by forcing them to obey different masters in school and state institutes. Teacher trainers from the state institute IQSH (institute for quality development) and researchers from the national institute for science education (IPN) worked with beginning teachers in the second phase and mentors at a school of these teachers. The idea of the Schleswig-Holstein model was to get away from the old model of study seminar, where only one expert teacher was the main contact person for the beginning teachers moving away from an apprenticeship model toward a more reflective model. The new approach used training modules offered by different persons of the IQSH. Beginning teachers have to learn about these modules and get support from the persons responsible for the module in the IQSH during school visits and mentors at school. The new idea of the work in Schleswig-Holstein with modules and mentors is to be more reflective in teacher education. Questions arise, how this model supports reflective mentoring, how mentors are qualified to participate in reflective practice and what kind of background beginning teachers were bringing to the school as reflective partners.

Method of tracing innovative aspects of mentoring and gender differences

Six beginning teachers and one mentor of a secondary school in Schleswig-Holstein were asked to participate in the study during the time period of August 2008 and November 2009.

At first a mentor was asked in an interview about the newly introduced official teacher education concept and its adaptation at school, the main tasks of the mentor and the coordinator at the school, the training and certification of mentors. In addition the mentor assembled documents about state requirements for the certification of teachers, the school concept about teacher education and guidelines from the coordinator.

In 2009 a second point of data collection followed with a questionnaire and semi structured interview for beginning teachers. Questions were raised about topics in teacher education, support of beginning teachers' work, collaboration, autonomy and workload in daily practice, gender specific differences and factors for success or failure of beginning teachers. In addition the beginning teachers were interviewed about their experience with the teacher education system and the mentoring process.

In order to trace these questions the model in figure 1 with reflective elements of collaboration was developed:

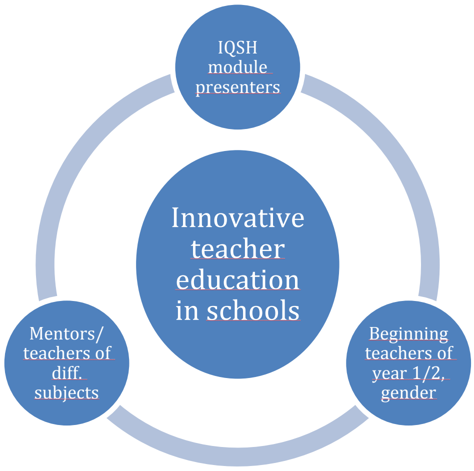

Figure 1: collaborative model about innovative teacher education in schools

In this model the complete system of reflections between mentors/teachers, beginning teachers and module offers of the IQSH teacher training institute for innovative teacher education is outlined. Each outer circle represents a community of educational actors that can interact through boundary crossing with a neighboring community. Within each circle further subsystems can be identified: teachers with or without a mentor status, teachers with different subjects, beginning teachers of consecutive years of training and different gender. It helps to interpret the kind of interactions in statements from questionnaires and interviews done.

RESULTS

Beginning teachers can choose modules in different subjects and educational topics. Persons from the IQSH present these modules in courses during a full work day in different places. Different modules can be offered by different presenters having different ideas about teaching principles and these teaching principles can be favoured differently by different mentors. Mentors are not always acquainted with the new modules in advance, but they are cooperating with the beginning teachers for preparation of lessons, more often on different levels such as offering practical advice and teaching outlines or discussing typical beginners' mistakes.

A problem with this system of modules is seen in the change of presenters and examiners. Beginning teachers do not have only one person for reference with publicly accountable expectations for their trial lessons and final examinations. This was judged to be more favorable in the old system where there were study guides in fixed groupings. In addition presenters of modules at the education institution and mentor teachers at the school do not have the same background and competencies. Mentors only have a general preparatory introduction into their tasks. These tasks are not related to specific goals for preparation of beginning teachers. A more specific training for mentors is judged to be more favorable.

Beginning teachers' answers in questionnaires and interviews partially reflected these critical points of missing coherence between theory in modules and school practice and contradictory demands for examinations. In the questionnaire they agreed that the modules for their subjects were helpful and that they got sufficient support and time for lesson preparation from the school. But they did not find some help in the modules about pedagogy and did not have enough time to cooperate sufficiently with the mentor teacher at the school or to discuss their work or experiences sufficiently with other beginning teachers.

Collaboration was not complete concerning the elements of the above model in figure 1 about innovative teacher education. Collaboration, reflection and exchange, in the larger more extended professional network, between the module presenter, beginning teacher and mentor teacher gives a chance of specific learning for all while linking theory of modules with the practical situation in the classroom. In an interview a beginning teacher is complaining about a lack of specific preparation of mentors for this networking:

> *"In general mentors are not well trained. This is obvious ... we as beginning teachers experience, that we are trained very well for the module and then we give our knowledge to the mentors ... They don't know much and in our meetings for consultation the mentors are those, who can say the least about the given lesson. There should be done more so that trainers become trainers, which are now simple teachers who guide us – nothing more."*

To a certain extent a culture of cooperation and autonomy seems to be fostered through partnership based mentoring. Especially beginning teachers from Schleswig-Holstein report a relatively high degree of autonomy and satisfaction about cooperation with colleagues. But the opportunities for beginning teachers to discuss their work with mentor teachers were estimated to be low. Nonetheless it was lower-order co-operation on the practical and technical aspects of professional work that seemed to dominate the mentoring process.

Content of subjects and its theory in modules seem to be separated from school practice. It clearly needs to be elaborated in congruence with mentor teachers. This point is explicitly made in the following statement:

> *"This is absolutely separate. There is something demanded from us by the IQSH [State Institute for Quality Insurance in Schleswig-Holstein] and what we are discussing there with other beginning teachers. And then there is the school, what happens there. And this is completely separated, which is a problem. On the one side we have to do what the module presenter is demanding from us, starting from educational standards, competencies and goals and on the other side in the school they say – pfff – curriculum, educational standards. This is mostly of no interest; they do not know what a curriculum is."*

Beginning teachers marked in the questionnaire that they missed to a high extent that the module presenters and others as examiners explained the criteria for the examination and that they did not get sufficient help for the examination paper at home. Concerning the demands from module presenters, mentors and the headmaster they feel that they have had to serve different masters with many opposite requirements.

As already mentioned the standards based modules are usually not well known by mentor teachers or principals at the school. This became a problem of agreement between this group of people responsible for the preparation and certification of examinations. In addition different modules may be offered by different presenters having different ideas and ideologies about teaching principles. These teaching principles might then be favored differently by different mentors as reported:

> *"The module presenters are not in agreement with their requirements at the end, although there are standards for that and information for preparation defining the criteria for correcting our exam home work ....One time it was required that I show my professional development as a teacher, what I have leant, how did I manage the lesson and how I profited from that personally. In the other homework I had to show how I supported the pupils, how did I use different criteria for the development of pupils? These are completely different tasks.... This is the point with the mentor that we shall do what we are required but he is not interested in educational standards or methods, there is only interest in subject matter, subject matter, subject matter. "*

A possible solution to bring greater levels of coherence to these divergent views might be to have a better collaboration between the various actors as suggested in the interview:

> *"I have experience about better exchange, defining the other mentor type. I always found out that mentors liked to get material we brought from the modules.... And I believe that it is meaningful that mentors and beginning teachers go together to module meetings. This I have done once with a Math mentor. This is something different, if you meet and can talk together about it."*

Beginning teachers personally experienced gender differences during their social interactions with the range of actors in their teacher education. They were asked a key question in this regard: How are male and female beginning teachers treated differently? The beginning teaches, especially the female beginning teachers, experienced a difference. They were complaining that their gender made a difference in discussions as pointed out:

"I experience a higher richness, when men are sitting with us in module sessions. This brings more objectivity in or another point of view, which is not too female."

Female beginning teachers said that they were treated differently in some ways. When there were only female beginning teachers together, discussions were completely different in the sense that there was no rigorous and a less aggressive demand.

In summary beginning teachers in Schleswig-Holstein seem to experience a high degree of support in their school. Nonetheless there is very little cooperation between initial teachers, beginning teachers and experienced teachers, other than with their specifically nominated mentor teacher. The partnership model of mentoring favored in Schleswig-Holstein does not seem to influence or even foster a culture of cooperation beyond the beginning teacher-mentor teacher relationship. The beginning teachers report very little collaboration within the full community of teachers at the school. There were few reported examples of higher order co-operation. Discussions on teaching experiences and lesson plans were scarce. Cooperative lesson planning rarely ever happens.

The many contacts of the beginning teachers do not in advance challenge an innovative mode of reflective teacher education. However many of the beginning teachers express themselves in the interviews in such a way that the mentors operate predominantly with a reflexive mentoring model.

A possible solution of these divergent views might be a better collaboration as suggested by one teacher. In this case collaboration and exchange between module presenter, beginning teacher and mentor is seen as a chance of specific learning for all, linking theory of modules with the practical situation in the classroom.

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PERCEIVED PROFESSIONAL DEVELOPMENT NEEDS FOR SAUDI ARABIAN SCIENCE TEACHERS

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Abstract: This research looks specifically at the perceived professional development needs for science teachers, so that continuing professional development (CPD) can be planned and implemented. The prime aim of this study was to ascertain the perceived needs of Saudi Arabian science teachers and science supervisors practicing in elementary, middle, and secondary schools. Science teachers were characterized by gender, school location, and area of specialization. The main instrument used was a questionnaire. The validity and reliability of the instrument were systematically established through relevant test procedures. The questionnaire seeks feedback on the main aspects of science teachers' needs, including generic pedagogical knowledge and skills, knowledge and skills in science subjects, managing and delivering science instruction, diagnosing and evaluating students, planning science instruction, administering science instructional facilities and equipment, integration of multimedia technology, and informal science learning. Additionally, the questionnaire covered the key science subject domains in which science teachers might need professional development. This study argues that science teachers' voices concerning their professional development needs are the key guide for their CPD.

Keywords: Teachers' professional development needs- Continuing Professional Development- Teacher Education

INTRODUCTION

Teacher professional development is a prominent feature on the educational landscapes of developed and developing countries equally. Experience around the world in developing, industrialized, and information-based countries has shown that professional development is the key determining factor for improved student performance. Effective professional development experiences are designed to help teachers build a new understanding of teaching and learning (Lee, 2001). Teacher development can be conceptualised as a mechanism for driving change in educational systems and/or as a strategy for empowering individuals and teams to improve their professional knowledge and pedagogy (Day & Sachs, 2004). Dillon (2010) argues that teacher development can either play a critical role in meeting teachers' needs and wants, or it can frustrate teachers and keep them from reaching their full potential. He also argues that teachers might both want and need professional development. In contrast, someone in a different profession, such as an inspector or a line manager, might identify that an employee has a need that they themselves are unaware of, such as a need for training in different questioning techniques. Nevertheless, for the purposes of this paper, we will explore the difference between the needs required for teaching science effectively represented by the inspectors' opinion, and the needs of teachers.

The continual deepening of knowledge and skills is an integral part of the development of any professional working in any profession. One important means of achieving competitive advantage is the creation of conditions for the rapid acquisition of new knowledge and skills. Teaching takes place in a world dominated by change, uncertainty and increasing complexity. Government publications all over the world, in Europe, North America and the Antipodes stress the technological, economic and social challenges which schools, and therefore teachers, face (Day, 1999). From the professional development view, Borko and Putnam (1995) argue that current educational reform recommends a shift toward a student-centred paradigm. This entails a substantial departure in teachers' approaches, from a traditional transmission of knowledge to a cognitive and social construction of knowledge. The tradition of 'in-service days' as the norm in professional development has been criticized as inadequate and inappropriate in the context of current educational reform efforts, and as being out of step with current research about teacher learning (Darling-Hammond & McLaughlin, 1995). One possible reason for the unsatisfactory results of in-service teacher training might be that the objectives of programmes were not congruent with teachers' personal and classroom needs (Baird et al., 1993). It might be reasonable to better understand the target audience before prescribing any intervention. Thus, to simply impose a training programme on teachers without considering their needs makes little sense (Noh, Cha, Kang, & Scharmann, 2004). Baird and Rowsey (1989) also highlight teachers' complaints that much time spent during in-service programmes and activities was wasted when such programmes did not meet their respective classroom needs. Loughran and Invarson (1993) argue that it is important that as a profession we are able to articulate what science teachers need to know and are able to do.

The concept of need has diverse interpretations. In the literature 'need' is used variously to mean a discrepancy, a recognized problem, the requirement for more services, and the wants of people (Stufflebeam, Mc Cormick, Bronkerhoff, & Nelson, 1985; Packwood & Whitaker, 1988). For this study, need is defined as the wants or preferences of an individual or a group of people. Need in this context is seen as a want (which implies interest or motivation) felt by an individual or group to eliminate a lack (Queeney, 1995). Without identification of teacher needs, poorly directed and inadequately focused interventions may emerge (Rhodes & Beneicke, 2003).

Educators acknowledge that the quality of science instruction is the main factor in developing meaningful understanding of science. Furthermore, the quality of science instruction cannot be achieved without qualified science teachers (Carey, 2004). Therefore, any mature reform of science education should emphasise science teacher professional development programs . These programs should help teachers develop in-depth knowledge of their disciplines as well as pedagogical content knowledge and skills (Mansour, 2010b). Consequently, the professional development of science teachers is widely recognised as a national priority (Obikan for Research and Development, 2010). The Excellence Center of Science and Mathematics Education ECSME at King Saud University in Saudi Arabia considers research in the professional development of science teachers as a key element in the reforming process of science education in Saudi Arabia. Therefore, ECSME launched a group to conduct a series of researches with science teachers and science teacher supervisors to develop a continuing professional development (CPD) program. The purpose of the program would be to support science teachers to take an active role in science education reform in Saudi Arabia. Accordingly, in the current study the research group aimed to identify and explore science teachers' needs in both content and pedagogical knowledge and skills as a first step toward making decisions and recommendations about the elements of CPD program(s) required for science teachers. The following two research questions were used:

1. What professional development needs in science content knowledge are identified by science teachers and their supervisors in Saudi Arabia?
2. What professional development needs in pedagogical knowledge and skills are identified by science teachers and their supervisors in Saudi Arabia?

METHODOLOGY

Instrumentation

To collect the data, the researchers developed a questionnaire based both on their experiences and on a review of a related study. The questionnaire includes 40 items (21 items for the science content knowledge domain and 19 items for the pedagogical knowledge and skills domain). Cronbach's coefficient alpha was used to calculate the internal consistency coefficients of the questionnaire. Results of the reliability analysis showed that the items in the instrument had a satisfactory discriminating power. Reliability coefficient alpha obtained for the whole instrument was 0.973; however, the coefficient alpha for the two scales were 0.978 and 0.973 respectively for the science content knowledge domain and the pedagogical knowledge and skill domain.

Collection of Data and Sampling

The population of this study included 2701 Saudi science teachers and 66 science teacher supervisors in four educational districts in different parts of Saudi Arabia (Jeddah, Alkarj, Alzulfi, and Almeqwah districts). These districts were chosen because they were parts of the partnership program with the Centre of Science and Mathematics Education which is the sponsor for this study. All science teachers in these districts were considered as the population and the sample of this study; a representative was hired in each educational district to distribute the questionnaire to all science teachers and supervisors in each educational district. A total of 499 Saudi science teachers and 61 science teacher supervisors responded to the questionnaire. For science teachers, the respondents included both sexes: 209 (42%) were female and 290 (58%) were male. Concerning subject specialism, it was found that the respondents were drawn from the following disciplines: biology 33.3%, physics 16.6%, chemistry 16.4%, earth sciences 2.0, other subjects (those who teach since for elementary students, but are not specialized in science) 27.1%. The 61 science teacher supervisors included both genders: 48 (78.7%) were female and 13 (21.3%) were male.

FINDINGS

The needs in science domains perceived by teachers and supervisors.

Table 1 summarizes the perceived needs of science teachers and their supervisors for professional development in various science subjects. As shown in Table 1, the 10 top needs perceived by teachers were the following: 1. nature of science and scientific inquiry, 2. modern physics, 3. structure and function of human systems, 4. genetics and evolution, 5. Electricity and magnetism, 6. earth properties and physical processes, 7. chemical reactions, 8. Forces and motion, 9. energy and 10. energy and chemical changes. These needs had a sequential priority mean of 3.53, 3.47, 3.46, 3.45, 3.43, 3.42, 3.41, 3.41, 3.40, and 3.39, respectively. In contrast, the 10 top needs perceived by science supervisors were the following: 1. the solar system and the universe, 2. Nature of science and scientific inquiry, 3.

Forces and motion, 4. plants, 5. climate and weather, 6. Structure and properties of matter, 7. Genetics and evolution, 8. Chemical reactions, 9. Earth properties and physical processes modern physics and 10. Energy and chemical changes.

These needs had a sequential priority mean of 4.51, 4.41, 4.25, 4.15, 4.02, 3.98, 3.94, 3.89, 3.80, and 3.78, respectively. Six out of the top 10 perceived needs were the same for both science teachers and their supervisors. These six needs are Genetics and evolution, energy, forces and motion, energy and chemical changes, chemical reactions, Earth properties and physical processes, and the nature of science and scientific inquiry. However, as shown in Table 1 the priority among these six perceived needs was different for science teachers and science supervisors, except for energy and chemical changes, which was ranked 10 by both science teachers and science supervisors. These findings might raise important questions about the validity of the science supervisors' voice regarding the CPD required for teachers. They also raise a question about the science supervisors' awareness of the science teachers' needs.

Table1
Science subject knowledge perceived by science teachers and by supervisors

No	Items	Science teachers		Science supervisors		t	df	Sig. (2-tailed)
		M	SD	M	SD			
1	Structure and function of human systems (biology)	3.46 (3)	1.088	3.75	1.004	1.673	546	.095
2	Epidemics: Causes and ways of prevention(biology)	3.38	1.115	3.48	1.047	.476	548	.634
3	Living things (biology)	3.33	1.103	3.49	.984	.772	545	.440
4	Plants (biology)	3.32	1.145	4.15 (4)	.951	4.954	541	.000
5	Genetics and evolution (biology)	3.45 (4)	1.159	3.94 (7)	.826	3.188	551	.002
6	Electricity and magnetism (physics)	3.44 (5)	1.102	3.73	1.056	1.910	545	.057
7	Energy (physics)	3.40 (9)	1.088	3.47	1.112	1.081	549	.280
8	Structure and properties of matter (chemistry)	3.32	1.101	3.98 (6)	.975	4.130	549	.000
9	Forces and motion (physics)	3.41 (8)	1.098	4.25(3)	.888	5.571	549	.000
10	Modern physics (physics)	3.47 (2)	1.149	3.77	.890	1.945	547	.052
11	Light and sound (physics)	3.40	1.137	3.72	.951	2.043	549	.042
12	Energy and chemical changes (chemistry)	3.39 (10)	1.120	3.78(10)	.937	2.359	550	.019
13	Chemical reactions (chemistry)	3.41 (7)	1.165	3.89 (8)	.958	-2.959	551	.003
14	Structure of matter and chemical bonding (chemistry)	3.36	1.125	3.46	1.104	.562	545	.574
15	Environment and the effect of environmental prolusion (biology)	3.36	1.127	3.75	.943	2.483	548	.013
16	Climate and weather (Earth science)	3.30	1.132	4.02 (5)	.956	4.514	541	.000
17	Earth properties and physical processes (Earth science)	3.42 (6)	1.115	3.80 (9)	.953	2.423	544	.016
18	The solar system and the universe (Earth science)	3.37	1.141	4.51 (1)	.698	7.468	547	.000
19	Nature of science and scientific inquiry	3.53 (1)	1.138	4.41 (2)	.761	5.732	550	.000

The number in parentheses represents the priority of the perceived need

An independent sample t-test was conducted to see whether there was a difference between teachers and supervisors in their perceptions of teachers' CPD needs in science domains. As shown in Table 1 there was not a statistically significant difference, except on three subject knowledge questions: living things, energy and structure of matter, and chemical bonding. The means of supervisors' responses of these three domains (3.33, 3.47, and 3.46, respectively) were higher those of teachers' perceived needs to the same topics (3.33, 3.40, and 3.36, respectively). This can be explained by the fact that the supervisors do not hold sufficient knowledge about teachers' needs concerning the science domains.

The needs in pedagogical knowledge and skills perceived by teachers and supervisors.

Table 1 summarizes the perceived needs of science teachers and science supervisors for professional development on pedagogical knowledge and skills. As shown in Table 2, the 10 top needs perceived by teachers were the following: 1. teaching science through field trips and scientific visits, 2. developing creative thinking among students, 3. teaching science for gifted students, 4. developing Science concept among students, 5. associating technology with teaching, 6. planning for teaching, 7. scientific inquiry instruction based in science, 8. Teaching science for special need students, 9. instruction based problem solving in science and 10. using concept mapping. These needs had a sequential priority mean of 3.68, 3.66, 3.64, 3.60, 3.57, 3.55, 3.54, 3.52, 3.51, and 3.50, respectively.

Table 2

Need of Pedagogical knowledge and skills as perceived by in-service science teachers and supervisors

No	Items	Science teachers		Science supervisors		t	df	Sig. (2-tailed)
		M	SD	M	SD			
1	Teaching theory, such as constructivism, behaviourism	3.50 (10)	1.038	4.28	.878	5.756	549	.000
2	Classroom management skills	3.28	1.155	4.38 (10)	.840	7.271	554	.000
3	Associating technology with teaching	3.57 (5)	1.122	4.36	.817	5.497	547	.000
4	Using labs in teaching science	3.55 (6)	1.189	4.46 (8)	.773	5.823	549	.000
5	Assessing students' learning	3.33	1.127	4.16	.970	5.520	548	.000
6	Planning for teaching	3.28	1.148	4.13	.903	5.748	551	.000
7	Connecting science to students' real lives	3.32	1.207	4.70 (2)	.691	8.688	550	.000
8	Scientific inquiry instruction based in science	3.54 (7)	1.113	4.69 (3)	.564	7.794	547	.000
9	Instruction based on problem solving in science	3.51 (9)	1.091	4.05	.884	3.894	549	.000
10	Using concept mapping	3.45	1.102	4.16	.840	5.072	544	.000
11	How to teach specific science topics, such as magnetism or writing chemistry equations	3.38	1.099	4.30	.955	6.138	554	.000
12	Questioning and classroom discussion techniques	3.32	1.176	4.42 (9)	.747	6.968	553	.000
13	Teaching science through field trips and scientific visits	3.68 (1)	1.111	4.74 (1)	.480	7.230	547	.000
14	Developing creative thinking among students	3.66 (2)	1.041	4.52 (7)	.748	6.066	546	.000
15	Developing science concepts among students	3.60 (4)	1.018	4.68 (4)	.596	7.873	541	.000
16	Teaching science for gifted students	3.64 (3)	1.074	4.56(6)	.643	6.771	540	.000
17	Teaching science for special needs students	3.52 (8)	1.183	3.98	.904	2.904	545	.004
18	Content analysis	3.42	1.040	4.60 (5)	.588	8.634	544	.000
19	Teaching science using learning cycle	3.49	1.052	3.95	.825	3.256	542	.001
20	Connecting science to other courses	3.41	1.093	4.00	.876	3.968	540	.000
21	Connecting science topics to each other	3.44	1.110	4.28	.878	389	484	.697

The 10 top needs perceived by science supervisors were the following: 1. teaching science through field trips and scientific visits, 2. connecting science to student the real Life, 3. scientific inquiry instruction based in science, 4. developing science concept among students, 5. content analysis, 6. Teaching science for gifted students, 7. developing creative thinking among students, 8. using labs in teaching science, 9. questioning and classroom discussion technique and 10. classroom management skills. These needs had a sequential priority mean of 4.74, 4.70, 4.69, 4.68, 4.60, 4.56, 4.52, 4.46, 4.42, and 4.38, respectively. Six out of the top 10 perceived needs were the same for both science teachers and supervisors. The six needs are these: 1. using labs in teaching science, 2. scientific inquiry instruction based in science, 3. teaching science through field trips and scientific visits, 4. developing creative thinking among students, 5. developing science concepts among students, and 6. teaching science for gifted students. However, as shown in Table 2 the priority among these six perceived needs by both science teachers and science supervisors was different, except for Teaching science through field trips and scientific visits, which was ranked 1 by both science teachers and science supervisors.

An independent sample t-test was conducted to see whether there was a difference between teachers and the supervisors in terms of teachers' CPD needs for pedagogical knowledge and skills. As shown in Table 2 there was a statistically significant difference between teachers' and supervisors responses, except that there was not a significant difference on one item—Connecting science topics to each other. The means of supervisors' responses on these three domains (M = 4.28) were higher that of teachers' perceived needs for the this skill (M =3.44). This can be explained by the fact that the supervisors do not hold sufficient knowledge about teachers' needs concerning the science domains.

DISCUSSION AND IMPLICATIONS

The majority of the teachers in the current study expressed a great need for academic and pedagogical training. The findings reflected that teachers perceive that they lack basic knowledge (e.g., chemical bonding, structure and properties of matter, forces and motion, and structure and function of human systems) and skills (e.g., planning for teaching, using labs in teaching science, and scientific inquiry instruction in science) to teach science. These findings might be interpreted as meaning that teachers believed their pre-service and in-service education did not help them in teaching science as it should be taught. Therefore, science educators should be aware of science teachers' professional needs in both pre-service and in-service training to use the pedagogies that can promote these 21st century skills e.g. teaching science for creative thinking, teaching science for gifted students, teaching science through field trips and scientific visits, connecting science to students' real lives etc.

The results from this study indicate that there is a mismatch between teachers' perceptions of their CPD needs and their supervisors' perceptions. While teachers are particularly concerned with the quality of science education, other stakeholders, such as science supervisors in this study, may have different priorities. In this sense, the findings of the current study concur with Park Rogers et al. (2006)'s study that the difference in beliefs among the stakeholders of professional development PD that has contributed to the gap between ideal and actual PD practice. Park Rogers et al (2010: 313) argue that "individual orientations to teaching science teachers do exist, can impact science teacher education activities, and can also change". A balance is required that addresses the concerns of everyone involved by reconciling competing interests. In this sense, Clandinin (1992, p.136) argues that teacher education should involve 'highlighting the tensions between personal and institutional narratives' so that reflection can be made to be powerfully relevant through focusing on the contrast between how teachers and institutions see each other and how they see themselves. Additionally, teachers' voices should be heard and taken into account concerning their perceived professional needs and the practical problems they face when implementing any new ideas in the classrooms.

The present study provided an insight for science teacher education. It will be useful for science teacher educators since it aims to meet science teachers' professional needs. According to Mansour (2010b), one reason why previous science education reform efforts have failed is because a consistent and coherent set of purposes, policies, programmes, and practices do not exist. Setting policies or curriculum frameworks at the state, county or even the school level can influence practice in the classroom, but may not ensure that science teachers will appropriately or consistently translate the policies into practice (Mansour, 2010a). Therefore, science teachers, supervisors, policy makers, and in-service and pre-service programme planners need to work together to consider the recommendations that have been identified in the teachers' professional development research.

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SCIENCE TEACHERS' PERCEPTIONS ABOUT THE RELATIONSHIP BETWEEN RESEARCH AND PRACTICE

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Abstract: This article discusses science teachers' perceptions of their own experiences in research or innovative programs, identifying positive and negative aspects of these experiences. Data was collected from 1290 science teachers within a large-scale questionnaire of TRACES project, developed in collaboration with universities from Argentina, Brazil, Colombia, Israel, Italy and Spain. Results showed around half of the teachers (44.7 %) have participated in some kind of innovative or research experience. These experiences are strongly cultural dependent. The high frequency on innovative programs (36,4%), which are usually proposed by public policies, indicates the teachers conception of innovation as produced externally, as something that is received in the school and reproduced (top-down). Teachers seem to assume a passive role in this process. The positive perceptions of these experiences were organized in the following categories: professional development; increasing in teachers and students autonomy; opportunities to develop peer-to-peer learning and good practices exchange; improvement of teachers' reflexive thinking; fitting the content to the context; development of procedural and attitudinal students learning; development of student's conceptual learning; and opportunities to experience research methodologies. The negative perceptions about teachers' participation in research were: lack of time and material resources; lack of engagement of the school community; lack of continuity and information about research results; lack of training and experience in research; administrative obstacles; and lack of connection between research and school context.

Keywords: teachers' perceptions; research experience; innovative experience; science education; TRACES.

BACKGROUND AND PURPOSE

This article presents partial results produced from the project TRACES - Transformative Research Activities: Cultural Diversities and Education in Science, funded by FP7[1], developed in collaboration with universities from Argentina, Brazil, Colombia, Israel, Italy and Spain. This project aims to identifying in each country the difficulties to bridge the gap between science education research results and the actual application of these results in teaching practice in schools. Within a transformative perspective, it also aims to involve all the actors (teachers, students, parents, researchers and policy makers) in the development of significant practices; as well as the elaboration of guidelines in order to improve scientific education.

TRACES project was structured in three main stages. During the first stage, in each partner country, consortium members carried out a survey of policies for science education improvement (national plans, projects and experimentations, curriculum reforms, institutional guidelines) implemented at national level during the last years. A parallel survey investigated the perspectives of

[1] TRACES: Transformative Research Activities, Cultural Diversities and Education in Science. *FP*7-*SCIENCE-IN-SOCIETY*-2009-1-*244898.*

the different actors (policy makers, teachers, researchers) involved in this process about the impact of those initiatives and of science education research, the possible barriers on the path towards their translation in actual teaching and learning practices at school. In the second stage, the consortium planned field actions in each partner country, inspired by the rationale shared in the first stage of the project and by research findings. The actions were designed and carried out by local project groups, involving the actors in an action-research process. In the third stage, lessons learned from the two previous phases will be put together and brought to a common ground at the consortium level, in order to compare results and come to a common reflection.

This article presents a development of the first stage of TRACES project, in which the science teachers' perceptions about their own experiences in research or innovative programs, as well as the positive and negative aspects of these experiences are investigated.

The research questions that guided this study were: (1) What are the science teachers` experiences in research or innovative programs? (2) What positive aspects are identified by the science teachers in their experiences in research or innovative programs? (3) What negative aspects are identified by the science teachers in their experiences in research or innovative programs?

RATIONALE

Different hypotheses have been investigated to account for a perceived lack of connection between research and practice. Hargreaves (1996, cited by McIntyre, 2005) complained that researchers often determine the agenda for educational research, and teachers are not even seeing the lack of evidence-based research as a problem in urgent need of remedy. For McIntyre (2005), the knowledge needed by classroom teachers in their everyday work and the knowledge that educational research is well equipped to provide are of two different kinds. Research-based knowledge may be used as a contributing element to pedagogical knowledge, but it cannot be simply translated into pedagogical knowledge. Teachers use to give priority to practicality, while researchers are obliged to prioritize values relating to the clarity and coherence of arguments and to the truth of their conclusions. The nature of research-based knowledge is impersonal and the nature of teaching is highly personal.

There is a myth suggesting that science teachers in the primary and secondary schools do not want to hear about educational research related to their field. Luft (2010) states that teachers are interested in talking to colleagues about emerging issues in science education, and to participate in science education research. While there are science education researchers and teachers who bridge the gap research-practice, few projects have significant collaboration in order to produce a shared product.

As pointed by McLaughlin and Black-Hawkins (2004), teachers use to see the conducting of research as an add-on activity, while colleagues from university consider schools as simple sites for their research. However, the authors present several patterns or models of school-university research partnership, from research conducted by individual teachers and their students to research conducted by teachers and academics for the wider audience of educational community.

The distinctions between schools and universities do not necessarily cause conflict, nor do they necessarily act as barriers to different forms of knowledge generation. However these partnerships are most successful where there is a shared understanding of these differences, as well as an acceptance of the appropriateness of one another's concerns, a readiness to be helpful wherever possible, and a recognition that each could learn much from the other (McLaughlin & Black-Hawkins, 2007).

The main challenges and dilemmas for all those engaged in collaborative school-university research are mainly the conditions to support the research activities, the roles of teachers and academics, and the nature of knowledge created. This article enquires the nature of these challenges from the teachers' perceptions with respect to their own views and experiences in research and innovative programs.

METHODOLOGY

This paper presents a qualitative research (Lüdke & André, 1986; Bogdan & Biklen, 1994; Flick, 2009) and it was based on science teachers answers for one question posed in the TRACES large-scale questionnaire, containing 36 questions, including opened and closed questions, applied to the six countries of the consortium: *Have you already participated of some innovative program or research inside or outside the university? (Yes, No) Describe the positive or negative aspects of this experience.*

The sample consisted of 1290 science teachers from all six countries. Of these participants, 577 teachers (45%) answered YES, informing that they have participated in some research or innovative program. For this study we analyzed the description of these experiences and the positive and negative aspects of these experiences, only those who claimed to have participated. The data analysis was restricted to teachers who are working with science subjects at primary and/or secondary schools.

To analyze the data we have associated quantitative and qualitative approaches, to obtain results with global and particular evidences about the science teachers' perceptions of their experiences in research or innovation. Regarding the qualitative data analysis, Alves-Mazzotti and Gewandsznajder (1998, p. 170) point out that "[...] this is a complex, nonlinear process, which implies in a work of reduction, organization and interpretation of data which accompanies the entire investigation ". In the present study, we used the Discursive Textual Analysis (DTA) (Moraes & Galliazzi, 2007). The DTA method of analysis is organized around four main stages: (1) 'Unitarization', characterized by the deconstruction of texts to identify and isolate ideas. This disassembly process results in 'units of analysis', which represent "elements relating to the phenomenon which is being investigated" (Moraes, 2003, p.195). (2) Categorization, in which the units of analysis are grouped into initial categories. In the subsequent step, the initial categories are grouped in a lower number and more comprehensive categories, called intermediate categories. Finally the intermediate categories are organized in a lower number of categories. The criterion used for the categories construction is the linkage with the ideas initially fragmented. (3) 'Meta-text', in which a rigorous analysis of the categories formed gives rise to the production of different text types, called 'meta-texts', which are continuously improved resulting in the construction of the final text, and comprises the description and interpretation. (4) Communication, the last stage of DTA, in which the constructed arguments are disseminated.

Therefore, DTA is an open methodology, a process of self-organization, consisting of construction, deconstruction, rigorous analysis and data validation. The validity and reliability of the results are guaranteed by the strictness with which each analysis step of the methodology is conducted (Moraes & Galiazzi, 2007).

RESULTS

The results showed that half of the science teachers (45 %) in our sample have participated in some kind of research or innovative experience. Among those who responded affirmatively, 59% described their experiences. Table 1 shows the frequency of teachers' participations in research or innovative programs for each country of the consortium, and the number of experiences described.

Table 1 – Teachers' participation in research or innovative programs for each country.

Countries	Total sample	Participation in Research/Innovative Programs (YES)	Experiences described
Argentine	436	134 (31%)	99 (74%)
Brazil	136	66 (49%)	20 (30%)

Colombia	170	136 (80%)	108 (79%)
Israel	64	36 (56%)	15 (42%)
Italy	279	94 (34%)	14 (15%)
Spain	205	111 (54%)	82 (74%)
TOTAL	**1290**	**577 (45%)**	**338 (59%)**

Among teachers who pointed their participation in research or innovative programs, it was possible to identify different types of experiences, highly dependent on the cultural background in each country (Table 2).

Table 2 – Type of teachers' experiences in research or innovative programs.

Type of Experiences	Frequency	Percentual
Innovation programs (regional/national/public policies)	123	36.4%
Research Projects (school-university)	73	21.6%
Short-term Training Courses	39	11.5%
Long-term Training Courses	35	10.4%
Other innovative programs (interdisciplinary X disciplinary)	33	9.7%
Others (developing teaching materials, using informal environments and training offered)	35	10.4%
Total	**338**	**100.0%**

The higher frequency of teachers' experiences was on innovative programs (36,4%), which were defined in this work as those science programs proposed by public policies. This number indicates that teachers' conception of innovation are usually identified as something produced externally, and received in the school for reproduction. This top-down innovation approach use to be led by public authorities or an 'expert bringer', and teachers seem to assume a passive role in this innovative process. For example, in Argentina, a high incidence of "science fairs" experiences (30%) as a research/innovative experience was identified. Considering that this Argentinean program is part of a national policy, the results increased the first category.

The partnership model with school-university developing a research project involving groups of teachers and/or students was the second most frequent experience. In Colombia, the high score of research experience (47%) seems to indicate a strong partnership school-university or, on the other hand, a non-canonical understanding of "research or innovative programs".

Teachers also identified their participation in short and long-term teacher training as a research experience, which includes short training courses on the one hand, and master programs in the other. Finally, interdisciplinary projects involving the whole school and the production of new teaching materials were also identified as research/innovative experiences.

The positive aspects highlighted by teachers were grouped in eight categories: improvement of teaching practice (51%); contribution to increasing autonomy of teachers and students (28%); opportunities to develop peer-to-peer learning and good practices exchange (20%); teachers' reflexive thinking (18%); fitting the content to the context (18%); students' procedural and atitudinal learning

(17%); students' conceptual learning (12%); and opportunity to experience inquiry-based methodologies (11%).

Chart 1 shows some quotes of positive aspects extracted from teachers' textual answers.

Chart 1 – Distribution of positive aspects of involvement with research, by category.

Category	Quotations about the participation in innovative programs and research
Improvement of teaching practice	*"It is positive for teachers, because they can improve their practice, which reflected positively in students leaning process"* *"First, it forces you to think about your daily practice. Secondly you know what is being done on the teaching of your subject. Thirdly you can learn and improve."*
Contribution to increasing autonomy	*"The project led me to a conceptual change, my approach to students and teaching has changed significantly. By becoming a facilitator instead of a source of knowledge I learned to believe in students' ability to succeed and achieve better."* *"The positive is that encourages both the teacher and students and parents learn investigating."*
Opportunities to develop peer-to-peer learning and exchange of good practices	*"I learned from my colleagues and felt the brainstorming advanced me."* *"Understanding and exaltation of the need to work on a common science teachers' network."* *"We share with our fellows, receive advice from different people which are 'experts'."*
Improvement of teachers' reflexive thinking	*"I learned a lot from working with developers. I learned new things about myself which I haven't noticed before, and improved my teaching, as well as learned about this interesting area."* *"It is a stop on the inertial operation for rework objectives of our work."*
Fitting the content to the context	*"The positive aspect lies in the contributions that can be done not only to scientific knowledge of the country and the world, but also make contributions to the area where you work and have a defined life plan."* *"Forces the constant reflection with peers or individually on what we want our students to learn and therefore helps to better relate to them."*
Contribution to students´ procedural and attitudinal learning	*"The fact of having done research, allows us to better instill our students with the advantages of the scientific method and critical thinking in any situation."* *"It created teamwork that favored the group of students, as evidenced the need for teamwork as an important part of the educational activity."*
Opportunity to experience research methodologies	*"It is positive to place the child in contact with scientific knowledge, where they can make observations, formulate hypotheses, register and assemble their notes, draw conclusions and transmit it to others."* *"The most positive thing was the guidance in the process to raise the research problem."*

Although these positive aspects, teachers that experienced research/innovative activities complained about: lack of time and material resources (43%); lack of engagement of the school community (27.4%); lack of continuity and information about research findings (21.4%); lack of teachers training and experience in enquiry (14.2%); administrative obstacles (13.2%); and lack of connection between research and school context (9.6%).

Chart 2 shows the distribution of the negative aspects pointed out, summarized in those six main categories. Moreover, some quotes are presented as examples, extracted from teachers' textual answers, in each category.

Chart 2 – Distribution of negative aspects of involvement with research, by category.

Category	Quotations about the participation in innovative programs and research
Lack of time and material resources	*"I see that there is a lack of incentives for institutional research in the organizations, whether in budget or logistics."* *"Not rewarded or recognized school teacher we do extra work to innovate in our classrooms".*
Lack of engagement of school community	*"The negative side is the resistance from many older and experienced teachers in accepting new teaching methodologies."* *"Often people who want to do different activities or proposals, are few. Sometimes they even are viewed critically by peers. Make innovation is hard work and not always appreciated by the rest of the faculty."*
Lack of continuity and information about research findings	*"The group of teachers who are part of innovation and research programs is always the same, hardly increases."* *"It was negative due to the lack of funding and the continuity of the research program. Teachers have difficulties to leave the classroom.*
Lack of teachers training and experience in research	*"The little ownership of some teachers with the proposed methodology."* *"It would be interesting to those who work at the basic level of primary or secondary could also enjoy and have the possibility of a sabbatical year as in the universities to devote to pure research."*
Administrative obstacles	*"Requires significant time and dedication has minimal recognition by the administration."* *"The feeling that there is a great personal effort, and there is very little recognition and support for continuing by the administration. The changes require the support and the duration is long."*
Lack of connection between research and school context	*"Sometimes they are working on issues or topics that are very difficult to implement in daily practice. Also sometimes these programs are not sufficiently disclosed."* *"Trainers sometimes do not prepare us for what we found in the classroom. Should be more practical. The paper bears all, but the day to day in the classroom has some problems that are not covered from the theory."*

In teachers' opinion, the most critical negative aspect of their involvement in research/innovative programs is the lack of time and material resources. They complain about the absence of effective support from faculty and school principals, expressed by their quotations about loneliness and administrative barriers. The lack of ongoing relationship with researchers is quoted by teachers, reinforcing the importance of a stronger, closer and continuous university-school partnership. Despite teachers complain about the lack of information about research findings, they believe the contribution of research findings can transform and modify teaching practice and the positive contribution of inquiry-based approaches is extended to students' learning.

CONCLUSIONS

The results show that the most common science teachers' experiences in research/innovative programs are those mentored by public authorities/research experts and collaborative research experiences. In both experiences, research activities are predominantly led by teachers, but restricted to classroom experiences with students of each individual teacher. The collaboration between groups of teachers and students, supported by faculty members is also identified in their experiences.

The main contribution of this experience, highlighted by science teachers, is their professional development, showing the importance of introducing inquiry-based activities in pre-service teacher training, which provides a critical opportunity to bridge the gap research-teaching practice.

In the teachers' perception in all six countries, there is a lack of incentive and support for research activities as a pedagogical activity developed in schools. Teachers see the conducting of research activities as an add-on activity. The engagement and commitment of school leaders to keep research activities in their own schools should be particularly valuable to overwhelm these barriers.

There is a coherent relationship between negative and positive aspects in the research experience. They complain about the lack of engagement and support of the school community in research activities, whereas in the other side, they indicate the opportunities to develop peer-to-peer learning and exchange of good practices as positive. As a counterpoint to the lack of teacher training in research, they emphasize this experience to empower teachers in research or inquiry-based methodologies. They complain about the lack of connection between research findings and school curriculum, and from the other side, research is seen as a way to fit the school content to the context of students and/or community.

Concluding, the challenges for bridging the gap between research and practice can be related to two contexts: the school context, which should promote support for teachers engagement in research; and the academic context, which should ensure the establishment of long-term partnerships, bringing academic research close to school context and improving teacher training in research.

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PATTERNS IN THE MEANING-MAKING OF SCIENCE TEACHERS INVOLVED IN A TEAM-BASED PD-PROJECT

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Abstract: The perceived outcomes of four science teachers involved in a yearlong school-based professional development (PD) project analyzing artifacts from practice in local science classrooms are examined through repeated interviews and are represented as meaning-making maps for each teacher. The teachers refer to various outcomes from the project and emphasize those parts of the project where they personally feel supported in relation to the current tensions they are experiencing in their professional work. Beside this there are similarities; all teachers refer to experiences from experiments in professional practice, and reflect on and interpret those experiences in relation to student learning. They also seem to grow to acknowledge the value of sharing practice through the facilitated collegial interactions.

Keywords: Professional development, meaning-making, in-service, professional learning, artifacts from practice

INTRODUCTION

It is acknowledged internationally that there is a need to improve science teaching, that science teachers are the key to this development and that professional development (PD) activities the teachers are engaged in can play a crucial role (e.g. Feinam-Nemser, 2001). In Denmark a number of science teachers have been educated to diploma level in recent years and act as resource teachers within their schools to support PD. However PD for most science teachers is still short, out-of-school courses detached from practice in spite of a growing consensus on the most beneficial approaches to teachers' PD. It appears that PD gains from being school based, focused on student learning, long term, content focused, and collaborative, and from incorporating inquiries into practice (Roth, 2007; Borko, 2004). The sharing of classroom videos in video clubs has been reported to produce a focus shift towards student learning (Sherin and Han, 2004), and there is a growing acknowledgment of the role played by cooperation among colleagues, teacher learning communities, with respect to an individual teacher's learning (McLaughlin and Talbert, 2006).

Teachers' professional learning can be seen as a change in knowledge and beliefs and/or a change in teaching practice (Bakkenes, Vermunt, and Wubbels, 2010; Borko, 2004). With a socio-cultural perspective acknowledged, and with the knowing and learning of teachers seen as constructed through participation in different aspects of local practice and discourse (Borko, 2004; Edwards 2001) research must seek an understanding of the teachers' experiences, how they make sense. The term meaning-making has been used for two decades in part of the research into students' learning in science classrooms (Abell, 1992; Mortimer and Scott, 2003). Meaning-making can when discussing (science) teachers' professional learning be conceptualized as a fine-grained perspective on their on-going construction of understanding and interpretation of experience in a particular setting or context.

The interconnected model of teachers' professional growth (Clarke and Hollingsworth, 2002) suggests that teacher learning occurs through the mediating processes of reflection and enactment connecting four distinct domains (situated in the change environment), namely:

- External domain: information, stimulus, and support from external sources;
- Domain of practice: professional experimentation in the classroom;
- Personal domain: teacher's knowledge, beliefs, and attitudes;
- Domain of consequence: salient outcomes.

Collegial interaction is part of the change environment surrounding all the domains, but in other studies collegial interactions are seen as the main field of interest in the domain of consequence (Van Driel and Beijaard, 2003). With learning communities as the focus for much contemporary debate and research more knowledge on collegial interactions is surely needed. However, empirical research looking into the individual teacher's professional learning in collaborative settings is lacking: knowledge regarding teachers' process of developing ideas and understanding while participating in learning communities, how they make use of inputs and how they engage in professional experimentation.

RESEARCH QUESTIONS

In the context of a collaborative project that uses artifacts from practice in local classrooms to focus on students' thinking and learning in science, the research questions are:

1. How do individual teachers reflect on the project?
    a) What outcomes do they identify?
    b) To which aspects of the project do they refer?
2. What links do the teachers make between a) and b), and what insight into their meaning-making do these provide?

THE LOCAL PD-PROJECT

The local PD project being the frame for this research is situated at a school that offers primary and lower secondary-level: grades 1 to 6 are taught integrated Science & Technology, while grades 7 to 9 have separate lessons for Biology, Geography, and Physics & Chemistry. All teachers who teach on of those science subjects are in the science team. Interviews before start of the project indicated considerable variation in the teachers' engagement in cooperation in the team and in developing science teaching locally. The idea to use artifacts from practice, in particular classroom video, to focus on students' learning in science, was presented by the facilitator (and researcher), but the project was situated at the local school and the particular themes raised were decided in the team. Facilitated experimentation with new tools and the collection of video data and other artifacts took during the yearlong project place between a range of half day workshops. Examples of collected artifacts and the work in the workshops are referred to below. The facilitator structured the discussions during the workshops and, when needed, offered input and tools from the knowledge base of research in science education regarding typical student preconceptions and alternative conceptions in science.

METHODOLOGY

Data were collected through semi-structured interviews. Interviews with participating teachers and the school pedagogical leader before workshop 1 were used to collect background data. Four teachers were then selected for an in-depth study focused on the teacher's science teaching during the project period and the PD experience. Purposive sampling was used to represent different levels of experience and teaching across a range of grades (Cohen et al., 2007). The four teachers were:

- Teacher A: novice teacher in her first year of teaching science, specialized in Science & Technology, teaching Science & Technology in 5th grade.
- Teacher B: in her third year of teaching, specialized in Geography, a non-specialist teaching Science & Technology across all 3rd grade classes.
- Teacher C: an experienced teacher specialized in Biology, teaching Science & Technology in 6th grade, has recently taken a diploma degree in Science Education acting as resource teacher for the science team.
- Teacher D: the most experienced/senior teacher, specialized in Geography, teaching 8th grade Geography.

The interconnected model (Clarke and Hollingsworth, 2002) was adapted as analytical model to facilitate analysis and representation of the complex interplays in relation to the teachers' meaning-making. The model was adapted with a new *domain of collaboration* to include the collegial interactions facilitated during the project (Van Driel and Beijaard, 2003) (Fig. 1).

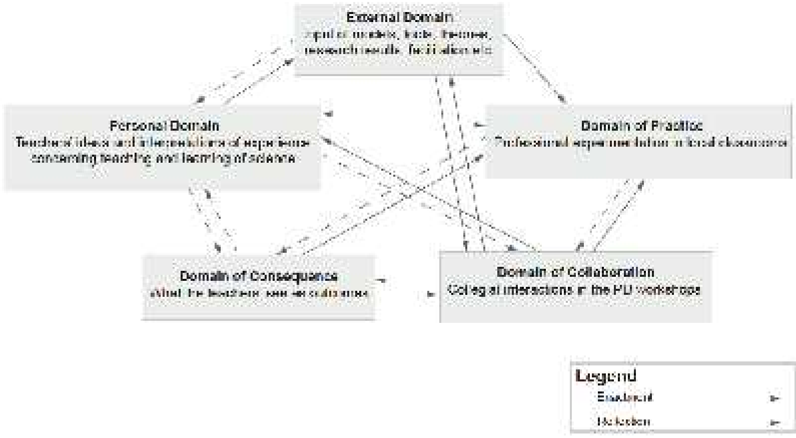

Fig. 1. Meaning-making model

The domains in the model are linked by the arrows reflection and enactment to represent how change in one domain is translated into change in another. When a teacher's reflection involves two domains, a reflection arrow is used between the domains; when the teacher refers to how something in one domain entails something in another domain, an enactment arrow is used. The final representation is called a meaning-making map. Clarke and Hollingsworth (2002) alternate between calling the illustrations change sequences and growth networks when interpreted as more lasting growth. The naming used here emphasizes the research aim: to examine teachers' perceived outcomes and represent their meaning-making.

In the first step of analysis interview transcripts were analyzed to identify utterances relating to each individual domain. In the second step utterances categorized as belonging to more than one domain in the first step were identified and the domains linked by reflection or enactment. For example, when asked about outcomes teacher B refers to her experience of teaching unfamiliar science content: "I think it has been really good teaching this electricity [..] while they simply loved to go to the science-lab and to do those experiments". The teacher reflects on something she sees as an outcome (domain of consequence) and links it to something new she has tried in her class (domain of practice), so a reflective arrow is made. Teacher B continues talking about this, saying that "in discussions in class [..] you could follow how various students [..] caught the point". A reflective arrow between the domain of practice and the personal domain represents her interpretation of experience in relation to students as learners. When referring to her professional work looking forward, she says she wants "to try new approaches in my class, like the one we tried with electricity". An enactment arrow from the domain of consequence to the domain of practice, represents an intention to build on this outcome through further professional experimentation.

The third step of analysis was a process of constant comparison to develop open coding categories that described the content of the of teachers' utterances referring to each domain.

FINDINGS

Findings will be presented as a meaning-making map and a pen-portrait for each teacher.

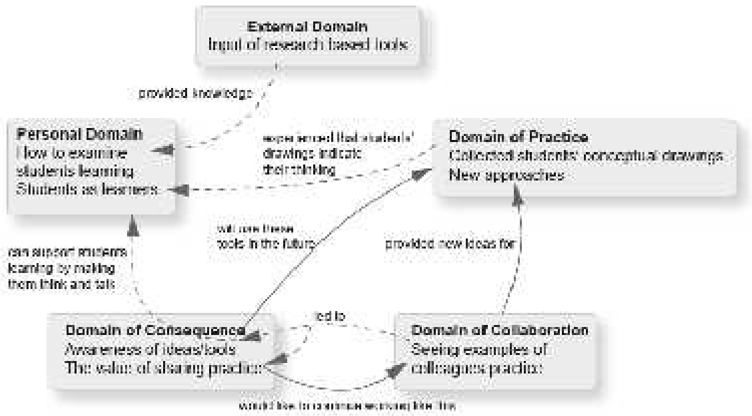

Fig. 2. Meaning-making map teacher A

Domain of collaboration can be seen as a key domain to understand teacher A’s meaning-making (fig. 2). The inspiration from colleagues is what she emphasizes as the main outcome. She refers to discussions about students’ thinking based on video from colleagues’ practice and how she became aware of the benefit of using tools like concept cartoons (Keogh and Naylor, 1999). Her emphasis on students talking science is developed along the project. In the first interview she focused very much on hands on activities as an ideal, but she also referred to having problems with classroom management sometimes letting the students do written work instead of experiments. In the second interview her emphasis is more on letting students think and talk than on activities in it-self. During the project she collected drawn and written artifacts to examine her 5th grade students’ understanding of cardiopulmonary circulation (Domain of practice). The students were asked to draw, in a pre-drawn shading of a body, the processes and functions of human blood circulation, following some lessons in physiology, where they, among other things, dissected the hearts of pigs. The drawings were discussed in on of the workshops. She did not refer to this in the retrospective interview until she was prompted, following her spontaneous reference to what was seen in her colleagues’ classrooms. However, when asked what she gained from this experience she reflected on and interpreted the students’ drawings, saying “it is clear that they draw the heart and not the lungs […] getting the lungs in and the two circuits, it was hard for them”. She also noticed that the students had a tendency to draw one-way blood circulation out from the heart.

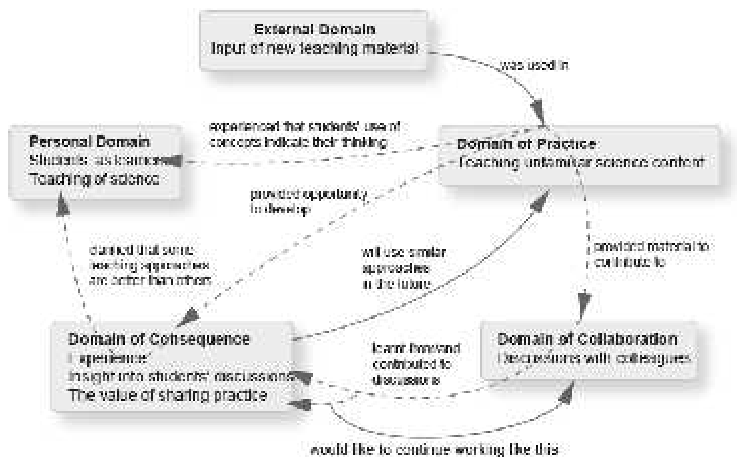

Fig. 3. Meaning-making map teacher B

Teacher B taught electrical circuits for the first time during the project (fig 3). In the interview she refers to the teaching material that involved continuing shifts between students posing hypotheses, their progressing experiments, and class and group discussions. Various artifacts from her 3rd graders, including video, were discussed in the workshops. Preconceptions from many 3rd graders were identified in relation to only one connection needed from bulb to battery or two ‘arrows’ from the battery meeting in the bulb. After a few lessons all the students referred to circuits and most students specifically attached the wire to two different places on the bulb. The domain of practice can be seen as the key domain in teacher B’s meaning-making map. Nearly all reflections are connected to this positive experience. It seems to have clarified for her that some teaching approaches are better than others. Referring back to an earlier experience at a local resource center, she states that too much emphasis was on ‘science as a show’ compared with the focus on students’ thinking used now. Teacher B also refers to presenting video and other artifacts from her classes in the team. In retrospect, she sees herself as having been passive in the science team before “I didn’t feel it was my field, I do not have very much physics*”,* but she values being able to contribute in the project.

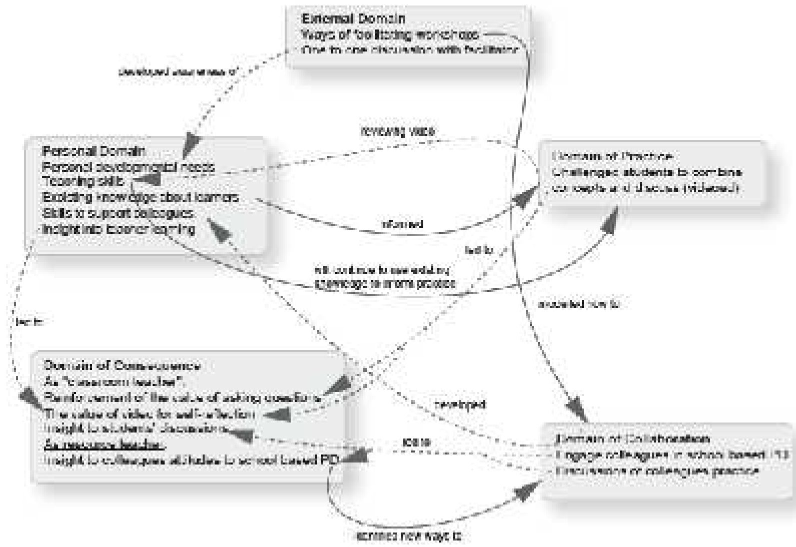

Fig. 4. Meaning-making map teacher C

Teacher C has the most complicated map (fig. 4) as nearly all her considerations involved reflections from being both a resource teacher and a classroom teacher. Her teaching in two 6th grade classes involved examining students’ preconceptions and their experiments with simple chemical analysis. The emphasis in the material she used was on the systematic approach, and before doing experiments the students discussed in groups what a criterion is and what classification is. As a resource teacher, she wanted more colleagues to be aware of this approach that she knew from her diploma. She backs her teaching on her existing knowledge about students as learners. Reviewing video informed her own practice; she mentions the value of asking questions instead of just giving answers. The project also informed her as a resource teacher, providing insight into her colleagues’ practice. She reflects on how you “learn as a teacher by seeing/doing it yourself, not just by being told”. In that way the domain of collaboration can be seen as another domain of practice for her. Being a resource teacher can be challenging, and teacher C through the project developed an awareness of personal developmental needs. She refers to one-to-one discussions with the facilitator and to being inspired by the way the workshops were facilitated: “It is good to get this from outside, so I also feel that I get some ‘feedback and support’ [she uses the term “sparring”]*”.*

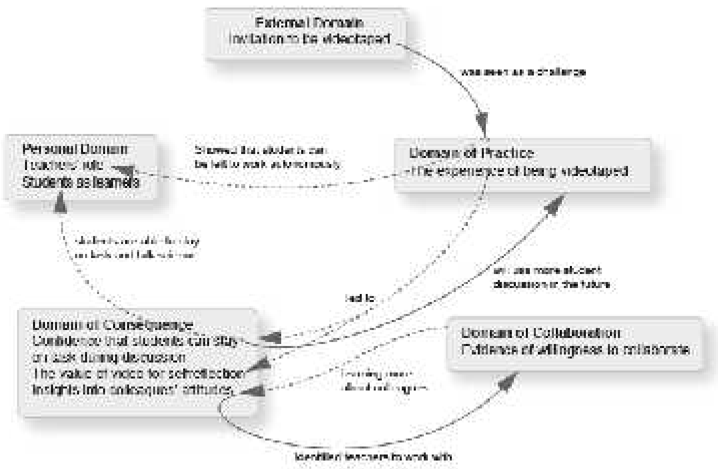

Fig. 5. Meaning-making map teacher D

During the project teacher D tried a tool inspired by concept cartoons to encourage 8th graders' to discuss the earth's climate. The students in groups discussed three suggestions by named imaginary young people. The 8th graders were very engaged in the discussion, contrary to what teacher D had expected; she had thought before the lesson that this was 'a piece of cake', as the theme had been taught in 7th grade. In a workshop the students' misconceptions, such as distance from the earth as an aspect rather than tilt and angle of incidence, were identified. The video and post-lesson essays from the students revealed how they, through discussion and purposeful questioning from teacher D, developed largely scientifically correct explanations, expressed in their own words. Teacher D's meaning-making map looks very much like teacher B's, but the experience of being videotaped per se is her focus. She does not mention presentation and discussions of video from her class in the workshops as teacher B does; it is her own self-reflection based on the video that she sees as an outcome. She refers to the science team as individuals pulling in various directions, and emphasizes the lack of cooperation between lower secondary science teachers. The project, however, has provided her with evidence of some colleagues' willingness to collaborate.

DISCUSSION

Teacher A's expressed idea about active self-regulated students seems to create a tension in relation to her coping with classroom management and so does her expressed wish to be able to answer all the students' questions, as she does not feel confident in physics. Novices struggling with classroom management, their activity orientation and low efficacy beliefs in the area of physics, which is also expressed by teacher B, are general challenges among Danish science teachers (Nielsen, 2011). In relation to A's meaning-making the interesting issue is that through her journey in the project she seemed to be in a development. She emphasizes inspiration from colleagues, which help her in the area of tension providing tools to see science as more than students' hands-on activities. Artifacts shared in collegial interactions seem to give her some event-structured knowledge to help see how the input from facilitator and colleagues can be used in concrete classroom situations. It might be that this way she gets ideas and efficacy to experiment more purposefully in her own practice. Teacher B's meaning-making map, her outcomes from experimenting with new approaches, can be seen as a general pattern. It has a close resemblance to patterns in teachers' learning mentioned in previous studies (e.g. Bakkenes et al., 2010). Teacher D's map shows nearly the same pattern and all four maps have reflective arrows between the domain of practice and the personal domain. In spite of local barriers there seems to be a growing awareness among the teachers of how they gain from collaboration for example teacher B when facilitated in developing her own practice seems to feel she has something to contribute to the team and when this is successful she gains even more confidence.

CONCLUSIONS AND IMPLICATIONS

The four informants emphasize various outcomes from the project; they seem to follow individual trajectories and in retrospect to identify outcomes connected to current tensions in their professional work. However all the teachers refer to their experiences from experiments in professional practice and reflect on and interpret those experiences in relations to the students' learning of science. In relation to implications for the design of PD, school-based projects give the opportunity for local experiments being shared collaboratively and such facilitated collegial interactions might be needed to acknowledge the value of sharing practice. This might lead to a continual effort to qualify local practice: potential generative development. School-based PD also serves the possibility to acknowledge individual tensions, which in this study has shown to be determent in relation to their professional learning.

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TEACHERS AS *LEARNERS* AND *DESIGNERS* OF ICT-DRIVEN SCIENCE CURRICULUM MATERIALS: FINDINGS FROM THE "ICT FOR INNOVATIVE SCIENCE TEACHERS" PROJECT

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Abstract: The purpose of this study was to examine the influence of a professional development course on teachers' evolved understandings of the ways ICT tools could be integrated in science teaching to scaffold and facilitate the learning process. The participants were nine physics teachers enrolled in 7 two-hour sessions that made use of two ICT tools. The course was organized in two phases. During Phase 1 ("teachers as *learners*"), the teachers were engaged in multiple cycles of data collection and analysis (through data sensing and logging), modeling (e.g., building, refining, testing, and validating models), video analysis, and investigation through the use of simulations. During Phase 2 ("teachers as *designers*"), the teachers re-designed an existing unit from their science curriculum to foster the development of understanding of the unit's concepts through the use of ICT tools. Data sources included teachers' responses to a written pre/post questionnaire about their prior teaching experiences with ICT, reflective diaries and teachers' lesson and unit designs. The findings revealed that the participants expanded their understandings of the various ways that ICT tools can be integrated within science instruction and they also shifted from the "authoritarian" model that dominated the majority of their initial designs to a more student centered approach through which the students use ICT tools for sense making, exploration, and knowledge construction. Additionally, modeling activities were very limited within teachers' revised lesson designs or totally omitted from their reconstructed units, a finding that points to teachers' inadequacy to develop epistemic awareness with respect to the purpose and the role of models and modeling in science teaching and learning. The paper concludes with a discussion of the relevant professional development issues and a set of recommendations about the underpinnings of ICT professional development courses.

Keywords: teacher professional development, ICT-enhanced teaching and learning, teacher understanding of ICT usage

THEORETICAL BACKGROUND

Although reform documents call for the integration of ICT tools in science teaching, it has been reported that teachers appear to have difficulty with creating classroom environments in which students are supported in creating their own constructions of knowledge through the use of ICT tools (Koehler, Mishra, & Yahya, 2007). A major factor that contributes to teachers' struggles with integrating technology into their teaching in a constructivist way relates to the absence of a theoretical framework from training seminars or professional development programs that guides the nature of technology integration into teacher learning (Hughes, 2004). As a result, ICT courses and workshops frequently tend to focus on providing teachers with technical skills necessary for operating the hardware and software (Kennewell, 2001; Zhao et al., 2002), and leave aside the pedagogical underpinnings behind the technological integration in science teaching and learning.

If we anticipate from teachers to become "technology integrationists" (Hughes, 2004), then teacher professional growth programs should aim to "… change teachers to teachers as active learners [by] shaping their professional growth through reflective participation in professional development programs and in practice" (Clarke & Hollingsworth, 2002, p. 948). Advocates of the *teacher as learner* approach emphasized the importance of designing professional development courses through which teachers should be offered "...opportunities for learning from teaching, rather than learning of teaching" (de Jong, van Driel & Verloop, 2005, p. 6). This *teacher as learner* approach moves beyond the traditional teacher preparation tradition through which teachers learn how to write good lesson plans or act as (passive) receivers of information about the various strategies of how to teach, as it places the teacher directly in the role of inquirer in simulated research experiences.

It is also equivalently important to give teachers the authority to act as designers of their own ICT-driven science curriculum materials, because engaging teachers in constructing a public artifact (e.g., their own curriculum) is a productive way to support their learning (Papert, 1991) and the transformation of their personal learning experiences into pedagogically potent curriculum designs. Teachers should take the role of active participants in any implementation or instructional reform we seek to achieve, and thus we need to offer them a certain degree of autonomy and power in making pedagogical decisions while designing and implementing their own curriculum (Mishra & Koehler, 2006). The idea of *teachers as curriculum designers* is based on the stance that teachers are "an integral part of the curriculum constructed and enacted in classrooms" (Clandinin & Connelly, 1992 p. 363), since their effort of curriculum development undergoes an organic process of iterative design, refinement and negotiation of a balance between technology, pedagogy, and content (Mishra & Koehler, 2006).

PURPOSE AND RESEARCH QUESTIONS

Grounded on the tenets of the teacher as *learner* and *curriculum designer* perspective described above, the purpose of this study was to examine the influence of a Professional Development Course (PDC) on the development of teachers' informed understandings about the various ways that ICT tools could be integrated in science teaching to scaffold and facilitate the learning process. Specifically, the two research questions that this study aimed to address were as follows: (1) *What did teachers' learn in terms of (i) how ICT tools are integrated in science teaching and (ii) the role of ICT tools in science teaching, as a result of their participation in the PDC?*; and (2) *How did teachers' ICT-driven lesson designs change as a result of their participation in the PDC?*

METHODS

Participants and Setting

The participants were nine physics teachers (7 males, 2 females) enrolled in a Professional Development science education Course (henceforth called PDC) that made use of two types of software, namely "Data-logging Insight" and "Coach 6". Five of them held a master degree in physics and all of them were at the time carrying a full teaching load. None of them had participated before in a course on how ICT can be integrated within science instruction.

The course was organized in two consecutive phases. During Phase 1 ("teachers as *learners*"), curriculum materials that were developed in the contexts of "Change of State" and "Forces and Motion" were implemented through which teachers were engaged in multiple cycles of data collection (through data sensing and logging), data analysis, modeling (e.g., building, refining, testing, and validating models), video analysis, and investigation through the use of simulations. After every session, the participants were asked to write reflective journals about their experiences and knowledge gained about the use of ICT tools in each session. During Phase 2 ("teachers as *designers* of ICT- driven curriculum materials"), the teachers were asked to reconstruct a unit from the school curriculum to foster the development of understanding of the unit's concepts through the use of ICT tools. As part of the requirements for their curriculum designs, teachers were asked to: (i) formulate learning objectives, (ii) provide descriptions of the design and the implementation of each activity, (iii) design activity sheets based on their activities' descriptions, and (v) design assessment tasks to evaluate their learning objectives.

Data collection and analysis

We collected multiple forms of data throughout the course; (i) teachers' responses to a written questionnaire about their beliefs and attitudes concerning the role of ICT in their teaching, and their knowledge and prior experiences regarding the use of data logging, modeling and video measurement software tools; (ii) teachers' initial and revised lesson designs that illustrate the use and role of ICT tools; (iii) teachers' reflective journals; and (iv) teachers' reconstructed units. The data were analyzed quantitatively using descriptive statistics and qualitatively using an open coding scheme refined through the use of the constant comparative method (Glaser & Strauss, 1967).

FINDINGS

What did teachers' learn in terms of (i) how ICT tools are integrated in science teaching and (ii) the role of ICT tools in science teaching, as a result of their participation in the PDC?

The analysis of the data collected from questionnaires that were administered at the beginning of the course, revealed that the participants had a very limited understanding of the ways that ICT tools can be integrated within science instruction to facilitate the learning process, as they stated that the teacher was the one that makes use of ICT tools and the ICT tools were used mostly for demonstration purposes within a science lesson. Evidence from teachers' reflective diaries during the course indicates that the types of activities that they were engaged with enabled them to expand their understanding of the various ways that ICT tools can be integrated within science instruction and they also appeared to have appreciated the multiple learning benefits from such integration. Specifically, the majority of teachers reported that throughout the course they learned how to analyse data with the use of specific software, identified advantages of the use of ICT in relation to the collection of more accurate measurements and performance of easier and faster data analysis, and appreciated the role of ICT in promoting students' interest towards science.

Apart from evaluating teachers' learning about the use, the role and contribution of ICT tools in relation to teaching and learning, we also examined teachers' evolved understandings about models and modeling, since they were engaged with modeling activities within the PDC. We summarize the findings from teachers' understanding of the nature of models and modeling in Tables 1 and 2 respectively.

Table 1. Teachers' understanding of the nature of models prior to and after the PDC

Category of response	Prior to the PDC	After the PDC
A model is …		
…a mathematical expression of a theory	1	-
…a specific environment for simulating or studying a phenomenon	1	3
…a construct (e.g., an apparatus, an algorithm) that we use to study a phenomenon	2	-
I don't know this term	5	-

...a set of mathematical equations that strengthen the description of a phenomenon	-	2
... is a program that runs on the computer and substitutes the experimental procedure. It produces error-free measurements and hence it helps in our understanding of the natural phenomenon	-	2
... the representation of a phenomenon with the use of a software. It needs to represent the phenomenon under study, provide a mechanism that explains how the phenomenon functions, and enable the formulation and testing of predictions	-	2

Table 2. Teachers' understanding of the nature of modeling prior to and after the PDC

Category of response	Prior to the PDC	After the PDC
Modeling is …		
..the simulation of natural phenomena in a specific environment	3	2
..a number of equations through which natural states are simulated in a way that information of how a phenomenon functions can be achieved	2	-
.. ..the process through which our understanding about how a phenomenon functions is represented in a model	1	1
..the use of a model from a theory to study a phenomenon	1	1
..the creation of a standard frame for studying a phenomenon	1	
..the creation of an artificial environment (or a simulation) for studying a phenomenon	1	4
..the creation of a model after observing a phenomenon. Next, the model can be improved through comparing it with the physical phenomenon. The model needs to represent the phenomenon and enable the testing of predictions. In case the model fails to fulfill these criteria, we need to return to the initial stage of modeling and revise the model accordingly	-	1

The findings reported in Tables 1 and 2 indicate that the participating teachers failed in making a substantial shift from their naïve conceptions expressed prior to the PDC to more sophisticated understandings of the nature of models and modeling. Although prior to the PDC the majority of the teachers were unfamiliar with the concept of "model", after the PDC seemed to have associated this concept with the software that was used for creating a model or simulating a phenomenon. In other words, they appeared to have conceived the models as technical tools and not as representational tools that facilitate our understanding about the underlying mechanisms of the phenomena being modelled. Likewise, the majority of the teachers after the PDC stated that modeling concerns the creation of an artificial environment or a simulation, a view that demonstrates their failure to conceive modeling as a process of developing and deploying models that account to our observations and serve as means to facilitate our understanding of a phenomenon.

How did teachers' ICT-driven lesson designs change as a result of their participation in the PDC?

The analysis of teachers' initial and revised lesson designs and the unit that they reconstructed was centered around the types of ICT that teachers chose to incorporate within their lesson designs, the role of the ICT tools in relation to the teaching and learning and the ways that the ICT tools were used to scaffold the learning process. We summarize the findings from this analysis in Table 3.

Table 3. Types of ICT tools and ICT-driven activities within teachers' initial and revised lesson designs and reconstructed unit

	Type of ICT-driven activity	Prevalence of each type of activity within the … initial lesson design	revised lesson design	unit reconstruction
1.	The teacher uses videos for demonstration purposes at the beginning of lesson to stimulate students' interest	4	3	2
2.	The teacher presents pictures through a projector connected to a computer at the beginning of the lesson to stimulate students' interest	3	0	1
3.	The teacher shows a simulation of a phenomenon under study to the students	3	5	2
4.	The teacher uses sensors to collect data from an experiment s/he performs	3	0	1
5.	The teacher presents graphs developed in a software of the data collected from an experiment	1	0	0
6.	The students work in groups and use ICT for data logging and data analysis	2	7	8
7.	The students work in groups and investigate a phenomenon through a simulation	0	2	2
8.	The students work in groups and use a modeling tool to construct a model of a phenomenon under study	0	2	0
9.	The students work in groups and use a video analysis software of a phenomenon under study	0	1	1

The findings reported in Table 3 indicate that at the beginning of the course the majority of teachers chose the use of ICT for demonstration purposes (see types of activities 1, 2 and 5 in Table 3). Even in the case of integration of a simulation within the initial lesson design (see type of activity 3 in Table 3), the way that the simulation was suggested for use was again for demonstration purposes and not for the investigation of a phenomenon through the manipulation of the variables of the simulation. This type of ICT use was consistent with teachers' prior experiences and knowledge that were reported in the questionnaire prior to the PDC and presented in the previous section of the Findings.

Another interesting finding that was revealed from the data collected for answering the second research question and merits attention relates to "who" will be using the ICT tools during the implementation of the lesson design. All but two teachers described that they themselves would use the ICT tools and not the students. Hence, we might assume that the teachers prior to the PDC felt that either the ICT is a powerful tool that is used only by the teacher who is willing to make her instruction more interesting and compelling or that their students would not be able to use the ICT tools appropriately due to lack of skills on how to use them or that the ICT tools could not be used as learning tools to enhance students conceptual understanding or the development of reasoning skills.

Evidence from the analysis of teachers' revised lesson designs and the unit that they reconstructed revealed that, after the course, the teachers shifted from the "authoritarian" model that dominated the majority of their initial designs to a more student-centered approach (see types of activities 6 through 9 in Table 3) through which the students use ICT tools for sense making, exploration, and knowledge construction. Specifically, after the course the majority of teachers suggested that they would organize their students to work in groups and they would let their students to use the ICT for data logging and data analysis.

However, modeling activities were very limited within teachers' revised lesson designs or totally omitted from their reconstructed units, although they engaged in several modeling activities during the PDC. A possible explanation that accounts for this failure might relate to teachers' inadequacy to develop epistemic awareness with respect to the purpose and the role of models and modeling in science teaching and learning, as it has already reported in the findings presented for research question 1.

CONCLUSIONS AND IMPLICATIONS

In this study we aimed to explore whether a Professional Development Course (PDC) that builds upon the premises of teachers as *learners* (Clarke & Hollingsworth, 2002; de Jong, van Driel & Verloop, 2005) and teachers as *curriculum designers* (Mishra & Coehler, 2002) could impact on the development of teachers' informed understandings about the various ways that ICT tools could be integrated in science teaching to scaffold and facilitate the learning process. The findings revealed that during the PDC the participants expanded their understandings of the various ways that ICT tools can be integrated within science instruction and they also shifted from the "authoritarian" model that dominated the majority of their initial designs to a more student centered approach through which the students use ICT tools for sense making, exploration, and knowledge construction. We believe that by allowing teachers to design their own curriculum materials, we offered them opportunities to think of issues like "How does ICT-driven instruction look like in practice?" or "What do I expect from my students to develop during their engagement with ICT-driven activities?" Hence, we argue that without teachers' personal involvement in developing these materials, the understanding of the role of ICT tools in science teaching and learning, to the extent that appeared to occur because of their personal involvement, would not be possible.

However, the participating teachers seemed to have not developed informed understandings about the nature and the role of models and modeling since the modeling activities were limited within teachers' revised lesson designs or totally omitted from their reconstructed units. A possible explanation that accounts for this failure might relate to teachers' inadequacy to develop epistemic awareness with respect to the purpose and the role of models and modeling in science teaching and learning. This finding is in line with what Justi and van Driel (2005) found in their study, as they reported that even though teachers received information about how to integrate modeling principles in their science instruction, they were neither became committed to such approaches nor felt that their instruction would be more effective and productive by applying them. Consequently, we suggest two important revisions/additions to the format of our PDC in order to succeed on helping teachers to design and implement modeling-based activities for their future implementations. We elaborate on these suggestions in the following sections.

The first revision we would like to suggest relates to the design of extra activities during the first phase of our PDC (Teachers as Learners) that would engage the participants in more explicit epistemological discourse about models and modeling. For instance, after the teachers develop a model about a phenomenon they observe, it is important to prompt them to reflect on (i) the procedure they followed for developing their model (e.g, did they follow a linear procedure or a cyclical one? what were the several phases they went through for developing their model and what did they do during each phase?), (ii) the nature of their model (e.g., what aspects from the phenomenon are represented within their model and why did they choose these aspects to incorporate to their model), (iii) the criteria they should use for evaluating their model (e.g., representational coherence, explanatory power, and predictability), (iv) the role of creating models within science instruction and in science in general. By engaging teachers in the abovementioned epistemologically oriented activities, we expect that the teachers will develop epistemological awareness about models and modeling and thus they would think of similar activities when whey will design their own curriculum materials.

The second and more major revision we suggest concerns the addition of an intermediate phase between Phase 1 (Teachers as Learners) and Phase 2 (Teachers as Curriculum Designers) through which teachers as curriculum thinkers this time, would engage in several reflective activities through which they will be given the opportunity to view and analyse ICT-driven curriculum materials from a pedagogical and instructional perspective. For instance, we propose that this new phase would engage teachers in the study of the underlying pedagogical and technological underpinnings of the curriculum that were engaged with during acting as learners or other ICT-driven curricula. Several prompts for reflection (e.g., *What learning objectives are promoted through each activity? How the development of conceptual understanding is promoted in the curriculum? What is the role and contribution of a specific ICT tool in the curriculum? What is the added value that the ICT tools bring in the curriculum?*) would be added in order to scaffold teachers' thinking. Some representative reflective prompts are as follows:

In summary, we conjecture that any professional development course that aims to help teachers to become effective technology "integrationists" should give emphasis on the development of their ability to (i) understand, consider, and choose to use technologies only when they uniquely enhance the curriculum, instruction, and students' learning, and (ii) to interpret new technology concepts through their professional knowledge – the knowledge that both consciously and subconsciously directs their daily teaching activities (Hughes, 2004). As a result, teachers are anticipated to use their general pedagogical knowledge, subject matter knowledge, and pedagogical content knowledge (Shulman, 1987) to identify promising, innovative ways that technologies may be used to teach their subject area (Margerum-Leys & Marx, 2002).

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PRE-SERVICE PHYSICS TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE IN DIFFERENT TEACHER EDUCATION PROGRAMS

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Abstract: The current discussion about the reorganization of teacher education programs resulted in a rising interest in (physics-) teachers' professional knowledge. This field, however, lacks empirical research concerning the professional development within the university part of teacher education programs. Against this background, a paper-and-pencil-test was developed to measure different aspects of professional competence including pedagogical content knowledge (PCK). Based on a measurement of competence in a group of 430 students in lower and upper secondary level teacher education programs, our study compares those different programs in order to determine their efficacy. Furthermore, our study presents results concerning the development of physics student teachers' PCK and its interplay with other domains of professional competence. In this context, the duration of the education, the amount of CK and the final school exam grade were identified as relevant predictors of students' PCK. Additionally, conclusions are drawn concerning the validity of the test approach. Apart from several pilot studies, a specific study is conducted to validate the paper-and-pencil-test regarding beginning teachers' action competence. Therefore a video based instrument was developed to measure science teachers' quality of performance in real classroom situations.
Key words: PCK, teacher education, professional competence, physics

PROBLEM DEFINITION

In recent years, unexpected and disappointing results of large scale assessments like PISA and TIMSS have led to a broad discussion about reasons and necessary changes of science education in Germany. The assumption that science teachers do not acquire sufficient competencies and skills for "high quality" instruction within their teacher education programs causes a rising interest in what are important aspects of – especially physics – teachers' professional competencies and in how these are implemented in education programs. Despite of many interesting approaches and projects, there is still a lack of empirical research findings concerning these questions. Up to now it is unclear to which extent needed competencies and skills are acquired and what their development is like especially in the pre-service phase of teacher education.

In the area of Physics, this study exemplarily shows a possible procedure how to operationalize pre-service teachers' pedagogical content knowledge (PCK) and how to develop corresponding instruments according to theoretical principles. Furthermore, a specific study is conducted to validate the paper-and-pencil-test regarding trainee teachers' action competence. Therefore a video based instrument was developed to measure science teachers' quality of acting in real classroom situations.

Physics Teacher Education in Germany

German teacher education programs are highly variable between different federal states. Nevertheless they have a common general structure. A first academic phase of teacher education with a duration of three or four years is followed by a one to two years lasting practical phase of in-service teacher training. In most federal states there are two different physics teacher education programs for secondary level schools, which emphasize different aspects of science instruction according to different school types and mainly vary in the "depth" of the implemented content knowledge in physics. According to this, differences concerning the acquired competencies in these two education programs can be expected.

Objectives

To get findings regarding the outcomes of different physics teacher education programs, this study aims on three main objectives. First (1) a model of pre-service teachers' professional action competence has to be conceptualized. In a second step (2), a quantitative instrument to measure different aspects of this competence has to be developed, piloted and validated, which can be used to analyze (3) the development of pre-service physics teachers' professional action competence in lower and upper secondary level teacher education programs.

THEORETICAL FRAMEWORK

Professional Action Competence

Summarizing the findings in the domain of investigating the efficacy of teacher training, Baumert & Kunter (2006) developed a heuristic model of professional action competence (fig. 1).

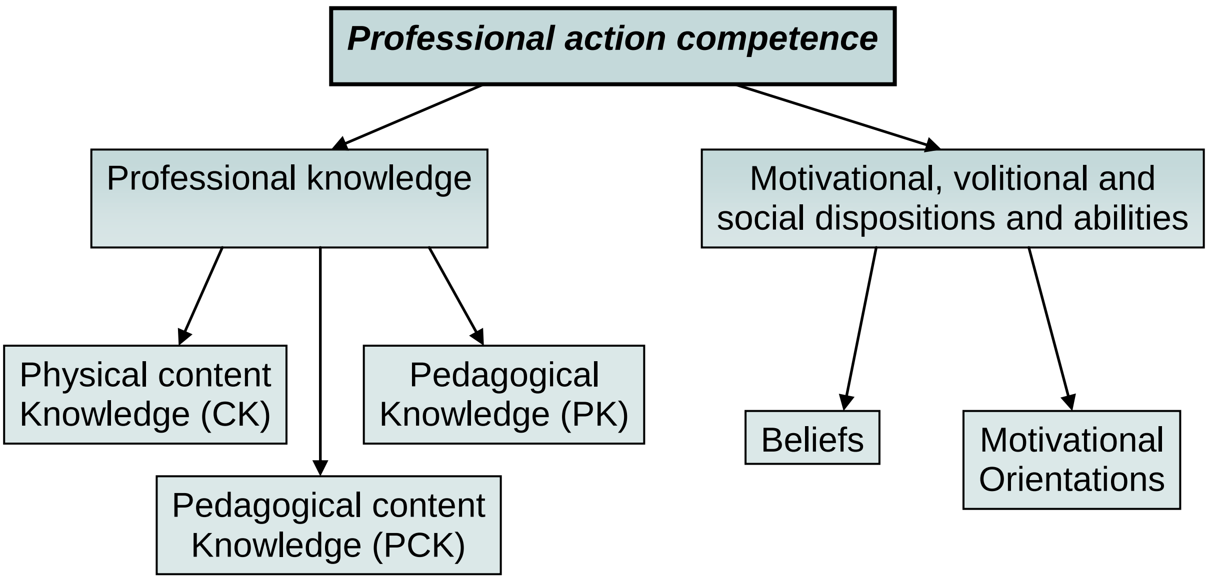

Figure 1 "Heuristic model of teachers' professional action competence"

At the core, the model draws on Weinert‘s (2001) conceptual classification of the concept of competence to characterize the structure and development of teachers’ professional competence. Thus, competencies refer to necessary prerequisites that have to be available for successfully meeting complex demands in a specific domain. Against this background, one aspect of professional competence reported in the literature is professional knowledge. According to a classification established by Shulman (1986) and widened by Bromme (1992), three aspects of teachers’ professional knowledge can be identified: content knowledge (CK), pedagogical content knowledge (PCK) and pedagogic-psychological knowledge (PK). Furthermore, it has to be considered that professional action competence, beside theoretical skills and knowledge, also comprises practical skills and knowledge up to the development of patterns of acting (Fenstermacher, 1994). Although there are further components of teachers’ professional competence like beliefs and personality factors (Jones & Carter, 2007), this article concentrates on the operationalization of PCK.

Pedagogical Content Knowledge

Shulman defines pedagogical content knowledge as a specific type of knowledge of professionals in the field of teaching and includes “the most useful forms of presentation of contents, the most powerful analogies, illustrations, examples, explanations and demonstrations […], the way of representing and formulating a subject that make it comprehensible to others” (Shulman, 1986, p.9f). Besides several other aspects, PCK also includes knowledge about typical difficulties in teaching a specific topic and especially students pre- and misconceptions. Shulmans’ concept of PCK formulated a base for various research projects in the field of teacher education and therefore was often widened, reconceptualized or adopted in many different ways. According to Lee & Luft (2008), the following dimensions of PCK can be formulated: subject matter, representation and instructional strategies, student learning and conceptions, general pedagogy, curriculum and media, context, purpose and assessment. To investigate education programs for pre-service physics teachers, these aspects of PCK have to be concretized according to the domain of physics.

OPERATIONALIZATION OF PCK

Because of limited time while surveying those differentl aspects of pre-servive physics teachers’ competence, there is a focus on the role of experiments as a specific type of physics instruction on the one hand and student misconceptions regarding the domain of mechanics on the other hand. The former decision is well-founded due to the importance of experiments in physics instruction. It has been observed that about 60 % time of a normal German physics lesson is related to experimenting (Tesch, 2005).

To make sure that all relevant aspects of competence are represented by tasks within the developed instrument, a framework of PCK in the domain of physics was designed while using normative models in terms of teaching physics on the one hand and observations of instructing-practice (e.g. best-practice-examples in video-based studies) on the other hand. So a best possible practice, based on teaching-related demands, is our starting-point. By applying these findings, the following relevant facets were identified: Knowledge about general aspects of learning physics, knowledge about a proper use of experiments, arrangements of learning processes, assessment and reflection of learning processes and finally an adequate reaction in critical situations in physics instruction. In these aspects a hierarchical progression from rather declarative aspects of PCK *(knowing that)* to rather procedural aspects of PCK *(knowing how)* can be seen (fig. 2).

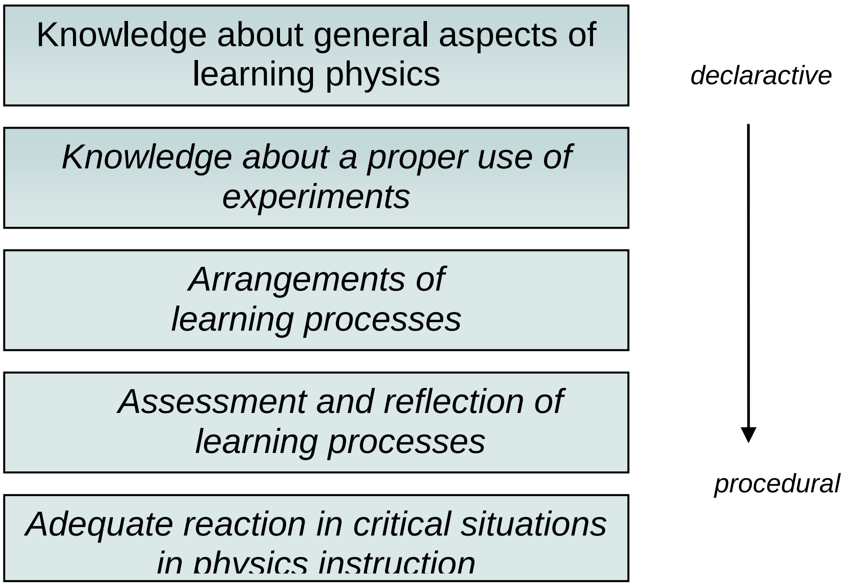

Figure 2 “Operationalization of PCK in physics”

METHODS

After concretizing the general structure of competence and the operationalizations of the diverse components of teachers’ professional competence, items for a questionnaire instrument were constructed to evaluate CK, PCK, PK, beliefs, attitudes and personality factors. To make sure that the instrument also assesses the (student) teacher’s ability to integrate, to associate and to apply the different components of competence, a pool of teaching-vignettes was developed. Teaching-vignettes are specific critical situations in the context of physics-lessons presented in the instrument, where the surveyed physics student teachers have to analyze the scene, to detect student misconceptions and to make a suggestion of how to continue in a reasonable way.

This instrument was piloted in a group of N = 45 physics student teachers attending one university. Afterwards the items were analyzed via descriptive statistics and factor analysis. Based on these analyses, the instrument was revised to get an empirically meaningful basis for further procedure. After that, the operationalization and parts of the questionnaire like the teaching-vignettes were validated by interviewing experts like experienced teachers, teacher trainers and academic physics educators. In doing so, the experts had to assess the critical situations with regard to relevance in respect of content and representativeness in a first step, and then they had to specify and categorize the tasks and problems. Finally, they had to explain how they would react in such situations in order to get adequate options for action within the sample solution. Moreover, the interviews were used to get further information to specify our model of professional competence of pre-service physics teachers. The once more adapted instrument was piloted in a group of N = 55 physics student teachers, now attending four different universities.

The main study was executed with about 430 students in lower and upper secondary level teacher education programs in several German federal states. For further validation, in a following study trainee teachers are investigated in order to explore to what extend components of their professional knowledge are related to distinct attributes of the quality of instruction regarding their classroom performance. While using the piloted questionnaire to assess their professional knowledge, a specific lesson (introduction of the force-concept in physics) are videotaped and analyzed regarding six main attributes of teaching quality in science instruction: coherent structuring, cognitive activation, motivational encouragement, scaffolding, classroom management and adequate use of experiments.

RESULTS

Psychometric Properties

After those steps of piloting the instrument, that was developed to survey physics student teachers' professional competence (see above), a well-working instrument is available now. The test's component related to teachers' PCK consisting of 39 items has a reliability of Cronbachs' $\alpha = 0.74$. Furthermore the shapes of the distributions concerning the test-persons' total score as well as the items' difficulties (fig. 3) imply that the instrument is neither too difficult nor too easy and that there is enough variance in the data.

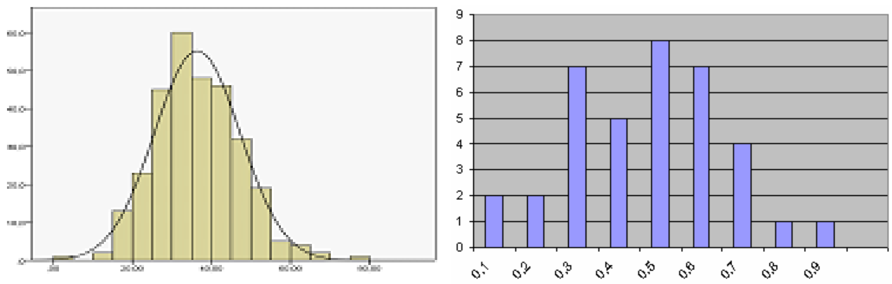

Figure 3 "Histograms referring to the relative total score in PCK (left) and the items' difficulties (right)"

In order to ensure the objectivity of the instrument, coding manuals with solutions based on literature as well as based on statements of experts (see above) were created. We found a good interrater-reliability randomly measured by intra-class-correlation (ICC = .91; $F(25,25) = 20.94$; $p < .001$).

We also carried out a criterion-related validation by comparing groups with different expertise levels (students, trainee teachers, teacher trainers) where we found increasing test scores for groups with greater expertise (ANOVA $F(2, 72) = 7.35$, $p = .001$). Finally, we tried to guarantee the construct validity by a combined data-collection with an independently developed instrument (Olszewski, 2010). We found a correlation between the two corresponding PCK-scores ($r = 0.64$) that was higher than the correlation of our PCK-part with our CK ($r = 0.45$) respectively our PK-part ($r = 0.49$) (fig.4). These correlations might indicate that PCK has a kind of middle-position between CK and PK and that CK and PK are prerequisites regarding PCK.

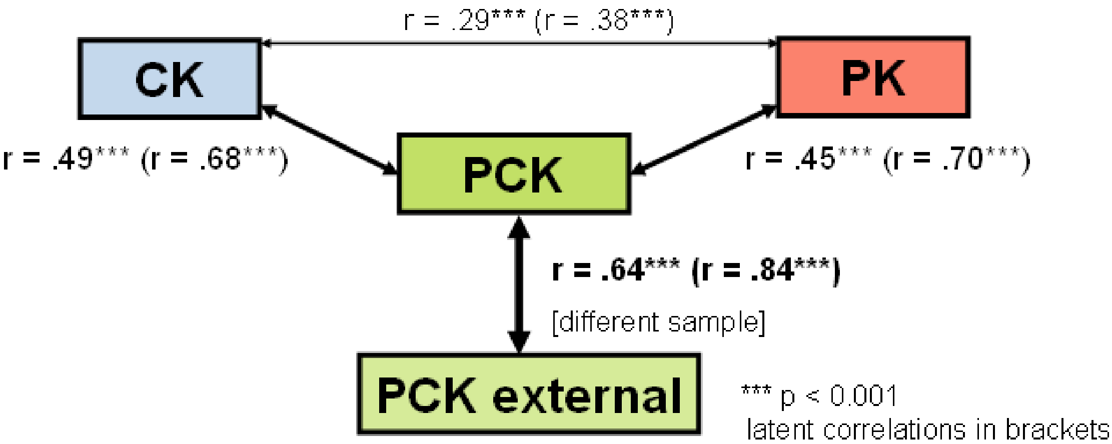

Figure 4 “Correlations within professional knowledge”

Comparison of different teacher education programs

In a first step, our study compares lower and upper secondary level teacher education programs. In a group of students within their last chapter of the academic study, we found significantly higher PCK-scores in upper secondary level programs compared with students in lower secondary level teacher education programs (p*< 0.001) (tab. 1).

education program / *professional knowledge*	*lower secondary level (N = 69)*		*upper secondary level (N = 69)*		*difference LL, UL*	
	M	***SD***	***M***	***SD***	***diff.*** M_{LL}, M_{UL}	$d_{LL,UL}$
CK	94.4	16.7	109.1	23.6	14.7 ***	.7
PCK	94.3	17.3	105.4	21.4	11.1 **	.6

Table 1 “CK- & PCK-Scores at the end of the academic part of teacher education”

Analyzing the reasons for this, we used a regression analysis to get findings concerning the development of physics student teachers' PCK. In this context, we found that the duration of corresponding parts of the education, respectively the amount of contact hours per week per semester, was identified as a significant predictor of students' PCK ($\beta = 0.15$, $p = 0.002$). This indicates that the lower secondary teacher education program is too short to bring out well trained teachers. Furthermore, the score of CK ($\beta = 0.38$, $p < 0.001$) and the final school exam grade ($\beta = 0.17$, $p = 0.001$) were further relevant predictors. In contrast, the total score in PCK doesn’t correlate with the number of corresponding college courses taken, which was used to measure knowledge in the past (cf. Abell, 2007). Apart from this, the number of semesters, the number of practical courses and student teachers’ gender were also no significant predictors regarding the score of PCK.

PCK and classroom performance

Concerning the relation between professional knowledge and classroom performance, very first results are available. In a pilot study, lessons of four trainee teachers and five student teachers were videotaped and the questionnaire instrument was used, too. The lessons were analyzed regarding six main attributes of teaching quality in science instruction coherent structuring, cognitive activation, motivational encouragement, scaffolding, classroom management and adequate use of experiments. Therefore high-inferent ratings of the teachers' actions in the classroom were carried out for every single attribute using four-point-likert-scales.

Rank correlations *(Kendall's Tau)* between the total PCK-Scores (N=9) and the ratings (on a scale from 1 to 4) show no significant correlation (as expected due to the small sample) (tab. 2). But there seems to be a tendency for a correlation between a teachers' performance concerning the cognitive activation of students in the classroom and the acquired pedagogical content knowledge (cf. Olszewski, 2010).

	Motivational encourage-ment.	***Cognitive activation***	***Coherent structuring***	***Scaffolding***	***Classroom management***	***Use of experiments***
PCK	*.141*	*.310*	*.171*	*-.141*	*.085*	*.059*

Table 2 „Rank Correlations between attributes of teaching quality and total PCK-Score"

But these results lacks validity as the comparability of the videotaped lessons is not sufficient because the student teachers mostly did not perform an introduction in the force concept.

CONCLUSION AND IMPLICATIONS

In view of the current discussion with regard to a reorganization of the first phase of teacher education, our study provides a statistically well working instrument to measure different aspects of physics student teachers' professional competence including PCK based on a theoretical model of competence. Surveying students of different teacher education programs, we are able to identify shortcomings and therewith potential improvements in the process of upcoming pre-service teacher education reforms. At the moment, our instrument is validated with regard to high-quality instruction by analyzing physics lessons in a standardized setting (introduction of force concept). After the data collection of the corresponding video study is completed, further in-depth analyses will allow detailed findings concerning the interplay of the different components of PCK (measured by the paper-and-pencil-test) and physics teachers' quality of acting in real classroom situations.

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TEACHERS' VIEWS ABOUT PRACTICAL WORK IN UPPER PRIMARY AND LOWER SECONDARY SCHOOL: ANALYSIS FROM A MODEL BASED INQUIRY PERSPECTIVE

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Abstract: Despite the important role that science education seems to give to practical work, research has reported during years a lack of effectiveness of the approaches implemented in the science classroom. The research presented in this paper proposes a model-based inquiry framework[1] for practical work and uses this framework to analyze teachers' views about it. These views are obtained by analyzing personal interviews on both teachers' perceptions and reports of practice, including the analysis of teachers' actual designs of practical work activities. From this analysis, some profiles are identified. Our first results indicate that, in general, practical work seems to be important for teachers despite the existing didactical approaches to it are quite traditional. Nevertheless, some of them are interesting to be taken into account as a possible point of departure for a model-based inquiry approach to science teaching and learning, bearing in mind the facilitators and limitations encountered by teachers identified in the analysis carried out.

Keywords: practical work, inquiry based science education, model based inquiry

INTRODUCTION

The interest of this research emerges from the results obtained within the research done during the first phase of TRACES[2] project, where a sample of n= 207 primary and secondary school teachers' answered a questionnaire related to their views regarding effective science teaching. First analysis highlighted the important role given to practical work, but also suggested the existence of a broad range of perspectives regarding its approach with some differences between primary and secondary school teachers' views.

In the light of these first results and considering the authors' interest on model based inquiry science education, the designed research was addressed to answer the question: *Which are teachers' views in upper primary and lower secondary regarding practical work and how these views can foster or hinder a model based inquiry science education?* This research then pretends to enlighten the research findings about practical work in the science classroom from the perspective of one of the didactical approaches that are being supported by the science education research community. To do so, the proposed research has three objectives: to propose a framework for practical work from a model-based inquiry perspective; to characterize upper primary and lower secondary school teachers' views regarding this framework; and to identify possible differences and similarities between primary and secondary school teachers' views from this specific teaching and learning perspective.

THEORETICAL FRAMEWORK

Practical work in science education

Practical work is usually considered as a quality indicator for science education. According to some authors it can facilitate the learning of some important scientific procedures such as observation, hypothesis proposals or the analysis and interpretation of results and can help students to elaborate an appropriate image of scientific activity (Hodson, 1994). In spite of its potential, however, analysis of the practical work being traditionally carried out in school has pointed out a general tendency of practical work to be ill-conceived, confused, unproductive and lacking in educative value (Hodson, 1994). Due to this mismatch between what would be expected and what is actually carried out in schools, research has devoted a lot of effort in trying to clarify which should be the main objectives of practical work. Last studies conclude that these objectives are to develop in students: manipulative and observational skills, the ability to interpret experimental data and to plan experiments, the interest in the subject and a feeling of reality regarding the phenomena being studied in theory (Johnstone & Al-Shuaili, 2001).

For some authors, it is the last point mentioned which constitutes the main purpose of practical work that is to help students to link the real world of objects, materials and events with the more abstract world of ideas and theories (Tiberghien, 2000). Unfortunately, some research results show that there are few evidences about the inclusion of this purpose in the practical work designed by teachers.

Model-based inquiry as a didactical approach

Research seems to confirm, despite the lack of existence of definitive results regarding it, that teaching and learning approaches centered on learning by inquiry (Inquiry-Based Science Education or IBSE) produce positive results related to students' motivation and science learning (Minner et al., 2010). In this sense, there is a general consensus in the literature that IBSE is central for science education (Barrow, 2006), despite claims about IBSE not being the only strategy to be used in the classroom and possibly not an approach to learn all sorts of scientific contents.

Beyond these considerations, research reports a lack of agreement about what IBSE is referred to. In our study we will be based on the literature review made by Barrow (Barrow, 2006) to define the dimensions that characterize IBSE: a) the cognitive abilities that students must develop; b) an understanding of methods used by scientists to search for answers for their research questions; and c) a variety of teaching strategies that help students to develop their abilities of inquiry (a), learn about scientific inquiry (b), and understand science concepts. Regarding them, there is more research consensus regarding what has to be taught to students than how teachers should teach from an IBSE approach (Anderson, 2007). In last years, research has been focused on the dynamics of IBSE and how to bring it to the classroom because despite research has confirmed the feasibility of bringing this approach to science classrooms there are a lot of studies confirming that this approach has not reached yet the expected quality levels. Barriers, external and internal, have been identified when trying to bring IBSE to the actual classroom practices (Barrow, 2006).

Based on the National Science Education Standards of the NRC five essential characteristics are highlighted: 1) scientifically oriented questions that will engage the students; 2) evidence collected by students that allows them to develop and evaluate their explanations to the questions; 3) explanations developed, by students from their evidence to address the questions; 4) evaluation of their explanations, which can include alternative explanations that reflect scientific understanding; and 5) communication and justification of their proposed explanations. These five characteristics entail some hands-on but also minds-on activities for students that form what will be named as *IBSE cycle*.

Among the most important critics to the consideration of IBSE as a privileged teaching and learning strategy is that of relating IBSE good results to the measurement of students' enthusiasm instead of to the actual learning of scientific contents and relation of IBSE with mere procedural and manipulative tasks and learning. In her article Viennot (2010) urges for the need to develop a more conceptual component of IBSE approaches, seeking to guarantee students' understanding of scientific concepts. For the author, IBSE approaches should be addressed to systematize and organize scientific concepts (more theoretical or more linked to theory) even though these approaches are usually considered as too traditional.

Last aspect we think is essential to be clarified is referred to some epistemological problems that we can find in the IBSE approaches commented until now. We are talking about the fact that, depending on how it is interpreted, inquiry activities can be centered on students' local explanations (the ideas they induce from their experiments and research designs) without any connection with any scientific theory that is seek to teach and to be learnt. Some authors identifying incomplete inquiry practices make reference to practices that are influenced by what is called the *scientific method* (Windschitl et al., 2008) highly widespread among teachers and that gives an unproblematic image of science, oversimplified forms of reasoning and often theory dissociated. According to the authors, a very systematic science that tends to present a unique way of gathering evidences, directly from practical work and without a connection between concepts, laws, principles or scientific models. This approach leads to the superficial explanations mentioned before, that give only answer to a concrete situation but not going beyond. Facing this situation, the research that proposes another way of understanding inquiry having in mind constant connections between phenomena and theory claims for an inquiry that focuses on the construction of models: representations constructed as conventions within a community to support disciplinary activity (Windschitl et al., 2008) or reasoning structures that allow someone to generate predictions and explanations (Schwarz & Gwekwerere, 2007). This particular model-based approach to IBSE is in agreement with the aforementioned views of practical work connected with theory.

Practical work from the perspective of model-based inquiry

Trying to foster the implementation of inquiry approaches in the science classroom and according to some research results that confirm that practical work can help to the promotion of inquiry (Barrow, 2006), this research proposes a framework for practical work from a model-based inquiry perspective. Based on the traditional IBSE cycle mentioned before, a cycle for practical work could be defined taking into account the potentialities of practical work above mentioned (see Figure 1). Additionally, based on the proposals of a model-based inquiry perspective, we could locate this practical work cycle in two dimension space that include the objects' or observables' world dimension and the ideas' or theoretical world dimension. The ideas world must go beyond students' ideas and make reference to students' constructs that should be in agreement with the scientific theories we want students to learn. The observable world refers to the phenomena observed and the experiments carried out in the science classroom. In a model-based inquiry framework as the one proposed, practical work should be situated in these two worlds, as the context in which to promote scientific reflection and learning, connecting both worlds by a modeling process. Figure 2 tries to represent this proposal.

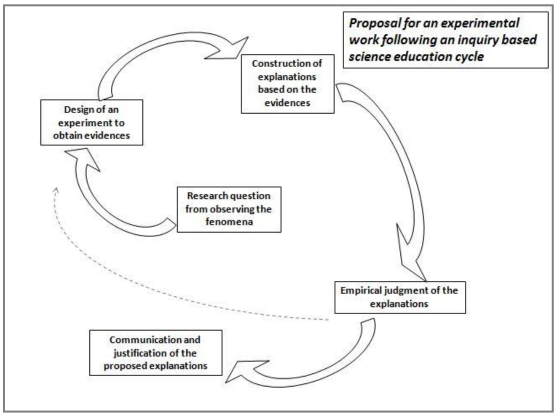

Figure 1. Proposal for a practical work following an IBSE cycle

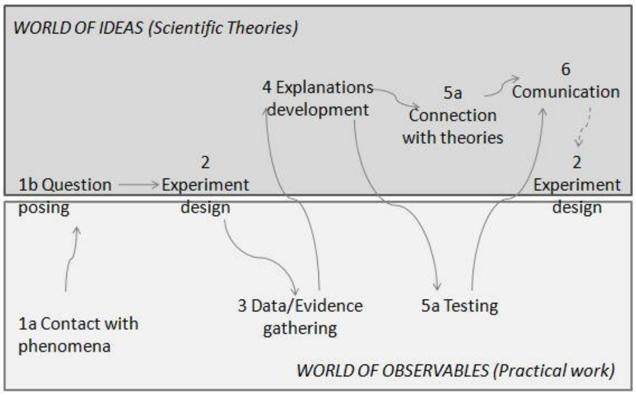

Figure 2. Practical work following an IBSE cycle: connections between the world of ideas and the world of observables

METHODOLOGY

This research is situated in a qualitative and interpretative research paradigm. Giving the interest of this research on the possible differences and similarities between primary and secondary school teachers, the study addressed the views of four upper primary (M1, M2, M3, M4) and four lower secondary (P1, P2, P3, P4) teachers from both public and semi-private schools.

Data collection

Trying to connect teachers' views regarding practical work to their own practice, the selected instrument for the data collection was a semi structured interview in which to discuss practical work teaching and learning activities both specially designed for the interview and also coming from the interviewed teachers. The interview was structured in three main blocks that are summarized in Table 1. All interviews were audio-recorded, being this the main source of data. Video data and other sources such as researcher notes and the documents related to the teachers' practical work proposals that guided the interview were used as secondary data.

Block	Description
Block 1 Practical work dimensions	Teachers' views about: main objectives, expected learning, role of practical work in classroom activities, format (including main students tasks), link with theory, teachers' role and evaluation.
Bloc 2 Personal experiences	Narration of own experiences as students regarding science and practical work; view regarding differences between primary and secondary.
Bloc 3 Opinion regarding non inquiry/inquiry activities	Teacher's selection according similarities with their own proposals between two practical work activities given by the researcher (both activities working the same concept, but one more closer to an IBSE approach)

Table1. Interview structure

Data analysis

Data analysis was carried out in three phases: a first analysis of teachers' views regarding practical work; a second phase in which, starting from the first phase results, some teachers' profiles were defined by considering the existing gap between their views and a model-based inquiry approach of practical work according to the proposed framework; finally, a deeper analysis regarding the factors that could be influencing the proposed profiles.

First analysis was done with Atlas.Ti, labeling those snippets considered more relevant taking into account some aspects coming from the theoretical framework (and already considered when designing the interview) and other ones that were emerging from data while making this first analysis. The considered dimensions were: *Practical work aims, Expected students' learning, Practical work structure, Students' tasks, Teacher's role, Link between theory and practical work, Limitations and facilitators to propose practical work* (in general and with an inquiry approach).

In the second phase and for each of the mentioned dimensions, categories that reflect a closer view to a model-based inquiry approach were identified, together with those reflecting a view not in agreement to this framework. Those requirements considered essential to *facilitate* inquiry, that is, fitting to the inquiry framework defined in this research, were defined for practical work *aims*, expected students' *learning*, students' *tasks* and *link with theory*. Those aspects that were considered to *hinder* inquiry as is understood in this research were also identified when characterizing a more traditional practical work approach or with a non modeling inquiry approach. Finally, some categories were identified that would *difficult inquiry to a higher degree*, being so far from an inquiry approach that the gap for a methodological change would be hard to be achieved. Linking the first and second analysis results, a deeper understanding of which factors could influence teachers' views was sought in order to be able to assess which mechanism could help teachers' views to evolve towards a model-based inquiry approach.

RESULTS

First results of the analysis were synthesized in sistemic networks in which teachers' answers were classified. By way of example, Figure 3 presents the one of the networks for the dimension "aims of practical work". According to this analysis, we could confirm that main aims considered by teachers were *motivation* in the case of primary school teachers, and *contextualization* of theory, for secondary school teachers.

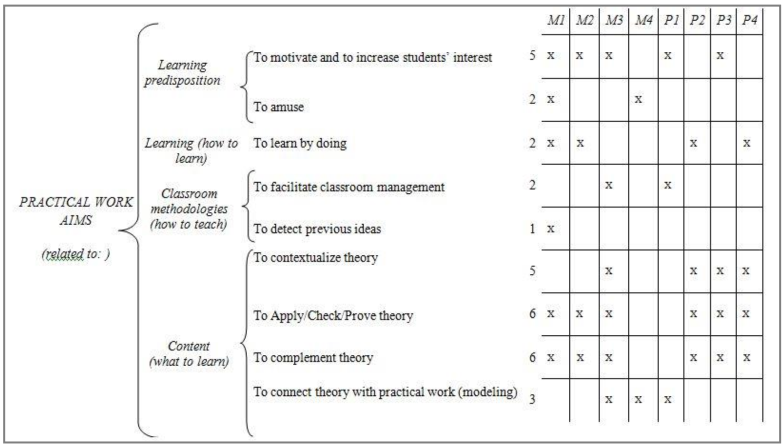

Figure 3. Analysis of teachers' answers regarding practical work aims

For the rest of the analyzed dimensions, some results could be highlighted. Regarding the expected learning, teachers tend to mention the learning of *science contents*, but other learning targets such as *cognitive abilities* or *nature of science* are less considered. When talking about the *tasks* students should carry out when being engaged in practical work, main references are made to *execution* tasks such as use of devices but there are few teachers bearing in mind important tasks from an IBSE point of view such as *planning* or *analysis*. Related to an important aspect of the framework defined in this research, the *link between practical work and theory*, most of the interviewed teachers tend to place theory before practical work, in a one way direction link in which once the theory is given, practical work can be started.

For the second phase of the analysis, some criteria were defined for the categories taking into account if they would *hinder* or *facilitate* an inquiry approach such as the one elaborated in this research. This criteria was used to classify teachers into *inquiry profiles (regarding their conception of IBSE)* as we will see further on. Following with the example of the dimension "aims of practical work", Table 2 shows this classification proposal.

	Practical work aims	
1	If only aspects related to learning predisposition (to motivate/to amuse) are mentioned	*Highly hinders inquiry*
2	If only aspects related to how to learn (empiricist view: learning by doing) are mentioned	*Highly hinders inquiry*
3	If only aspects related to classroom methodologies are mentioned	*Highly hinders inquiry*
4	If, when talking about content, only contextualization is mentioned	*Hinders inquiry*
5	If, when talking about content, the link between theory-practical work is considered but only in one way sense (theory→ practice or practice → theory)	*Hinders inquiry*
6	If, when talking about content, the link between theory-practical work is considered in both sense, with the objective of constructing models	*Facilitates inquiry*

Table 2. Criteria for teachers' inquiry profiles according to their views regarding practical work aims

Once these criteria were defined, also for the rest of dimensions and categories, teachers were classified into *inquiry profiles* considering if their views could hinder or facilitate a model-based inquiry approach for practical work. Taking again "aims of practical work" as an example, teachers were classified as shown in Table 4.

	M1	M2	P3	P4	P2	M3	M4	P1
Practical work aims	*Hinders inquiry*	*Hinders inquiry*	*Hinders inquiry*	*Hinders inquiry*	*Hinders inquiry*	*Facilitates inquiry*	*Facilitates inquiry*	*Facilitates inquiry*

Table 4 Analysis of teachers' views regarding pratical work aims from the perspective of model based inquiry science education

Applying these criteria and classifying teachers into profiles for the considered dimensions, a global *inquiry profile* was defined for the interviewed teachers' views (see Table 5).

	M1	M2	P2	P4	M3	P3	M4	P1
Global	*Highly hinders inquiry*	*Hinders inquiry*	*Hinders inquiry*	*Hinders inquiry*	*Hinders inquiry*	*Hinders inquiry*	*Facilitates inquiry*	*Facilitates inquiry*

Table 5.Teachers' views profiles taking into account to what extent they facilitate a model based inquiry approach for practical work

Being these results quite revealing, with most of teachers (both primary and secondary levels) offering views regarding practical work partially far from an inquiry approach but with some potentialities to get closer to this approach, it would be interesting to go further on this analysis trying to identify which could be the mechanisms to make evolve these views by considering the facilitators and limitations mentioned by teachers themselves. To do so, the global profiles defined in the second analysis are correlated with the limitations stated by teachers, classifying these limitations as internal or external considering if they were directly related to teachers, their beliefs and their level of self reflection or if they were more influenced by external factors, such as structural limitations. Figure 4 presents this correlation. As we can see in the graphic, teachers with naive views of inquiry, far from the proposed framework do state both external and internal limitations, although for primary school teachers only external limitations are mentioned. On the other hand, teachers with more sophisticated inquiry views do only state external limitations, which would suggest that for these teachers internal ones have been overcome. Finally, there is only one case in our sample with views further from an inquiry approach, which makes hard for this study to draw any conclusion despite it seems that both external and internal limitations are present.

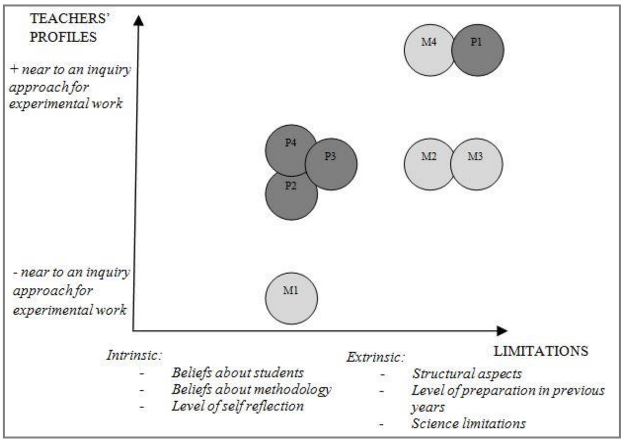

Figure 4. Proposed profile for the classification of teachers' views about inquiry practical work. Correlation with stated limitations.

Trying to overcome these limitations, also an analysis of the possible facilitators should be done. In one hand, for teachers with medium inquiry views, that is those presenting some potentialities to use a model-based inquiry approach in their practical work, we could say that this view was favoured in situations in which they have collaborated with other colleagues or when they have been involved in some specific projects (such as an ICT project). Also when they master the subject they are teaching they feel more confident to carry out different approaches such as an inquiry one. On the other hand, both teachers presenting a profile that virtually fits with the inquiry framework proposed in this research had in common that they have had a regular contact with research and innovative groups, being an important mechanism to be taken into account.

CONCLUSIONS

This research has made possible to elaborate a framework to characterize a way of proposing practical work that fits within an inquiry based science education (IBSE) approach, specifically that of model-based inquiry. The analysis of the interviewed teachers' views regarding practical work from this framework suggests that, despite the existence of some differences between primary and secondary school teachers' views, there is not too much to highlight regarding these differences. Practical work has still an important role for teachers in science education, but the proposed approaches are quite traditional which would suggest that a renovation of this practical work inspired in the proposed inquiry framework could be beneficial at two levels: first, to take advantage of practical work potentialities, widely highlighted by research in science education; and second, as a first step to bring inquiry approaches closer to the science classroom by introducing this perspective to guide something that it is already done. In this sense, the fact that the majority of the interviewed teachers present views with some potentialities for an inquiry practical work, would suggest the feasibility of this approach.

Regarding the methodology proposed for this research, the fact that the interview has been developed around teachers' own practical work designs has make possible to analyze their views from an approach closer to their real teaching practice. On the other hand, to give to teachers the opportunity to see a traditional practical work activity transformed into an inquiry approach (block 3 of the interview) has allowed teachers to contrast their own teaching practice with both alternatives, helping to emerge the limitations and facilitators that could condition their day by day selection between one and the other approach. Finally, we think that the proposed dimensions and categories for the analysis of teachers' views can be used as a basis for future large scale studies.

NOTES

[1] The inquiry framework developed in this research has been carried out in the context of discussing the nature of scientific competence in the I+D project COMPEC "Análisis de dificultades, propuestas de formación y elaboración de materials didácticos como "buenas prácticas" en el ámbito", ref. EDU2009:08885, Ministerio de Ciencia e InnovaciónTransformative

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DESCRIPTION OF PRACTICE TEACHING FROM THE SYSTEMATIC OBSERVATION OF THE WORKING CLASS IN HIGH SCHOOL

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Abstract: Addresses the practice of teachers of science, research phenomenon through a detailed analysis of previous classroom sessions video-recorded, three in average teacher, "from an" Analytical Model of Teaching Practice, from Systematic Observation ', in which each session is divided into 5 minute clips to be analyzed, having a total of up to 10 clips per class session, to record the frequency of video-recorded events which identifies the presence or absence of actions of each of the five categories of analysis of teaching practice, previously established role of student, teacher role, learning object, the object of evaluation and assessment concerning ", which allows statistical manipulation data.

The characterization of work in the classroom of high school science teachers, we can provide information regarding the key elements that constitute the practice of teachers. Preliminary results show academic activities typical of a traditional practice, characterized by the absence of experimental activities, making it necessary to rethink the training and retraining of teachers in the exercise of basic education in Mexico.

Keywords: teaching practice, systematic observation, science teacher education, working class

INTRODUCTION

-The Problem

Previous research work on teacher's initial and in-service training (Rodríguez & López-Mota, 2006) reports that despite teachers taking many in-service courses, there are few signs of significant changes in teaching as well as in learning science. This leads us to think that there is a problem with the nature of work developed within the classrooms that is not easily changed by either initial training or in-service courses. So it seems interesting to know why it is so hard to change it, by understanding what it is the kind of teaching practice displayed within the classrooms.

Recent studies about the teaching practice, based on video recorded sessions, have given solid empirical basis to develop quality teaching (Roth et al., 2001; Duit et al., 2005). Nevertheless, several researchers (Lederman, Wade & Bell, 1998; Tsai, 2002) express their concern for having at not hand much more needed results on what happens within the classrooms at schools.

With this research we wanted to characterize what happens within classrooms -as a direct phenomenon of study- by analyzing detailed previously recorded sessions -three on average for every teacher- taking on board an analytical model of teaching practice, based on systematic observation.

-Framework

The teaching practice has been studied under several perspectives: practical implications from theoretical perspectives (Pozo & Gomez, 1998; ethnographical approaches (Candela, 1999) and description of the phenomenon (Duit et al., 2005; López-Mota, Rodríguez, Flores, Martínez & Antonio, 2007; Rodríguez, 2007; Flores, 2009).

The first perspective towards teaching practice is derived from theoretical stands of learning traditional, discovery, significant and constructivistic- but does not offer empirical evidence to justify such categories. The second one comes from an ethnographical point of view and describes cases of what happens within classrooms, but having problems in developing large scale studies because of its methodology. The third one -in which is based the present study- offers an advantage: the systematic description of teaching practice (Flores, 2009) who has defined analytical categories and empirical indicators of pedagogical actions of teachers within the classrooms.

RATIONALE

This type of investigation might bring new light to establish educational policies, based on extended empirical data and bring about changes in the nature of the teaching practice in the classrooms. We think it is eventually possible to develop a theory of teaching practice if we base our descriptions of what happens in the classroom, in an analytical model that is as well based on systematic observations. This means, with the aid of cognitive theories of learning and analytical categories coming from observation: a strategic blend of *apriori* and *aposteriori* procedures.

METHODS

To characterize the educational practice of natural science teachers, through its detailed analysis of video-recorded class previously, we initially set out to build a *'Analytical Model of the Teaching Practice from the Systematic Observation*' (*MAPADOS*) -by its Spanish acronym- (López-Mota, López, Rodríguez & Flores, 2010), which is constituted two categorical systems whose behavioral taxonomies are the product of previous work (López-Mota et al., 2007; Flores & López-Mota, 2009) and from the conceptual level. The first categorical system, which is used in this work, consists of five analytical categories: *student role, teacher's roll, object of learning, evaluation object and references for evaluation.* This taxonomy has the virtue of indicators, from 4 to 10 for each category, originate from an empirical analysis of classroom observation (Flores, 2009), giving a total of 29 shares for the 5 categories with which analyze teaching practice, which allows a wide range of actions taken by the teacher in the classroom work. By splitting the sessions in clips of 5 minutes you get a large number of events to analyze, the model proposes to sweep the observation of more than 50% of each class session, recording only what happens on the odd or even for clips each class session, but always recording what happens in the first and last clip of the class.The model implies that each videotape, for a class session, which in theory is 50 minutes, split into 5 minute clips to be analyzed, having a total of up to 10 clips per session of class to record the frequency of video-recorded events in which it identifies the presence or absence of actions of each of the five categories of analysis of teaching practice previously established statistical manipulation of data.

-Procedure

To make it possible to obtain the reliability of the observations, it was necessary that pairs of observations were made of each category in the same teacher. To then get the percentage of agreement, the margin should be at least 80%.We apply the methodology 1 of MAPADOS at a sample of 17 science teachers, biology, physics and chemistry in secondary schools from morning and afternoon in Mexico City.

RESULTS

The 17 teachers were observed in a total of 45 class sessions for an average of 2.64 sessions per teacher, as class time in schools is 50 minutes, total time, in theory, intended for these kinds of science was 37 hours. But when doing field work, we find that the reality was that the 45 class sessions lasted 28 hours and 9 minutes, which is losing roughly 25% of the time devoted to work with students.

Which does not lead to identifying a first point on which we must work in order to ensure the quality of education, especially when the faculty have spoken out against the curricular reforms by lower -apparent- content in the plans study.

By dividing the class sessions in clips of 5 minutes was possible to obtain a total of 331 events to be analyzed using 29 indicators, but because the model does not propose to analyze 100% of the session, but a scan class representative in this case 210 clips were found which means were analyzed 17 hours and 51 minutes, which gives a percentage of scanning for the analysis of the kinds of 63.41%, which is a fairly representative value of teaching practice. Concerning the characterization of teaching practice, Table No. 1 shows the results of the 17 teachers under the teachers' actions more frequently in the classroom. Table No. 2 shows the results of the 17 teachers under the teachers' actions less frequently in the classroom.

Regarding the most common registered shares in the class of teachers, it is noteworthy that occupies the first place-for the total sample, make reference to the behavior of the students: "Students keep composure before the intervention or activity performed by the teacher". And the other four refer to an expository teaching practice in which students act and interact primarily at the express request of the teacher. In contrast, the least favorable action in the classroom is referred to the students participate on their own initiative. The other four actions that are least in teaching are in the same vein, it does not refer to the possibility of interpretation of science or phenomena by students and the lack of real interaction between them and the teacher beyond listening.

Table No. 1: Stocks with greater frequency

Category	Action	Frequency	Subjects
Student role	I-6: Students keep composure before the intervention or activity conducted by the teacher	162	17
Object of Learning	III-1: The teacher displays or presents the content or phenomena using definitions and / or contextualized and / or instantiations, without room for interpretation by the students.	111	17
Teacher's rol	II-1: The teacher verbally, with or without teaching aids, described or set forth concepts and ideas of school knowledge	98	17
Student role	I-2: The student writes a specific request or at the direction of the teacher.	97	16
Student role	I-6: The student teachers expressed or spontaneously request a verbal response, written or graphic, or a direct challenge to the group in general.	93	16

Table No. 2: Stocks with less frequency

Category	Action	Frequency	Subjects
Student role	I-7: The student takes the initiative itself part of the exhibition of the teacher and express in their own words, to broaden the understanding of the learning object	1	1
Object of Learning	III-4: Teaching materials and resources used to define and / or contextualize and / or exemplify, with room for interpretation by the students.	7	2
References for evaluation	V-3: The teacher points out the differences in performances that have a student for himself.	8	4
Object of Learning	III-2: The teacher displays or presents the content or phenomena giving room for interpretation by the students.	10	3
Teacher's rol	II-6: Happens to teams during the implementation of a pilot, or not being able to interact with students	15	6

CONCLUSIONS AND IMPLICATIONS

We can say in conclusion that it is possible to account for the practice of teaching as a phenomenon of study, from the detailed description of it by categories of analysis that are reflected in the actions taken or not teachers at its class. As the core elements to characterize the work in the classroom of high school science teachers, we find that your practice focuses on the exposure of content through definitions and/or contextualize that leave no room for interpretation by the students, lack of laboratory practice into context the phenomenon to study and teaching practices that enable centralized interaction among students about scientific knowledge and assessment activities focused on compliance or otherwise of the activities tasks and / or product class and not in the analysis of individual performances of each student.

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IN-SERVICE BIOLOGY TEACHERS´ PCK DEVELOPMENT: ANTITHETIC ROLES OF SELF EFFICACY

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Abstract: The focus of this study was the development of pedagogical content knowledge (PCK) of two teachers during a professional development course in biology. Pre and post interviews as well as recordings during the course made it possible to track whether PCK was developed or not. Self efficacy was the central PCK component, enabling development in Bert's case and hindering it in Anna's case. This study demonstrates the importance of this PCK component and the importance of the connections between the components for integrated PCK development.

Keywords: biology, professional development, pedagogical content knowledge, PCK development, self efficacy

INTRODUCTION

The context of this paper is the development of a professional development (PD) course (Scheuch, Keller, Radits, & Pass, 2010) in biology to improve teaching of field ecology. The overall aim of the course is the development of in-service biology teachers' pedagogical content knowledge (PCK); the teachers choose the emphasis for their learning individually. In this study, which addressed the development of PCK of teachers through participation in this PD course, the PCK component self efficacy emerged as a central component enabling and disabling development.

THEORETICAL BACKGROUND

Professional Development

Reviews by Lipowsky (2010) from a pedagogical view and by Hewson (2007) specifically in science education research, have revealed the following factors for effective PD courses: 1) The duration of the course is important – the longer the course lasts, the more development can take place and the more of the content of the course is transferred to the participants' classes. 2) Exchange between the teachers and sharing work on their teaching are needed to further develop their understanding about what they are doing in class. 3) Teaching practice should be included, so the PD course should challenge the classroom practice within its programme as well. 4) The teachers' experience based on former practice and the practice conducted within the courses should be reflected. 5) PCK as professional knowledge domain should be addressed explicitly in the course by the teacher educators as well as the teachers. In studies which focus on the development of PCK in PD courses, the factors of effective PD have also been found (e.g. J. H. Van Driel, Verloop, & Vos, 1998: changing craft knowledge of teachers needs reflected teaching practice and the focus on the learning of the students).

Pedagogical Content Knowledge

Pedagogical content knowledge (PCK) is a domain of teacher knowledge (beside pedagogical knowledge and content knowledge), which is important for the teaching of a specific subject and even a specific topic (Shulman, 1986; 1987). PCK research is a very wide area, with lots of different conceptions and attributions of PCK. One tension has to be mentioned: Although it is described as the "*special form of professional knowledge*" (Shulman, 1987, p.8), it is individually developed and far from being a collective body of knowledge. Cochran et al. reacted with a constructivist conception in replacing PCK by PCKg (that means pedagogical content knowing and also includes more tacit forms of knowledge) or more recent Wieringa (2011) in her re-reading of Schön´s “The Reflective Practitioner” (1983) where she sees PCK as some kind of practical knowledge – opposing formal knowledge. These different characteristics are a result of the individual development of PCK, as it is developed by the teachers during practice of teaching and the reflection upon the practice (Park & Oliver, 2008; J.H. Van Driel, Jong, & Verloop, 2002); therefore it results in an individual or idiosyncratic knowledge (Park & Oliver, 2008; J. H. Van Driel & Berry, 2010). Abell (2008) asks for an overarching model of PCK development, because actually the developmental routes of the teachers are very isolated (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2008). Park & Oliver (2008) developed one model based on Magnusson, Krajcik et al. (1999), where the growth of the teachers’ PCK is central. Reflection in Action as well as Reflection on Action turned up to be crucial (Park & Oliver, 2008). In a most recent review about studies documenting PCK development, Schneider & Plasman (2011) have found general developmental pathways during teaching biographies for the several components within the PCK conception of Magnusson et al. (1999). So there have been and still are attempts in getting the development conceptualised; in this paper we take the model of Park & Oliver (2008) because this matches our intentions best. The six components are: Orientations to Teaching Science (OTS); Knowledge of Students’ Understanding in Science (KSUS); Knowledge of Science Curriculum (KSC); Knowledge of Instructional Strategies and Representations for Teaching Science (KISR); Knowledge of Assessment of Science Learning (KA); Teacher Efficacy (TE). Teacher efficacy was newly introduced into the model by Park & Oliver (2008) and labelled as “*an affective affiliate of PCK*” (p 270). They described that it “*was a highly subject specific version of teacher efficacy in that it was related to teacher beliefs about their ability to enact effective teaching methods for specific teaching goals*“(p 270).

RESEARCH QUESTION

Our research question addresses the development of teachers’ PCK in ecology: How does the teacher’s PCK develop by participating in our in-service PD course? In this paper we focus on the role of self efficacy in the development of PCK.

METHODS & PARTICIPANTS

The pre-post interview study follows a pragmatic research approach because the results should help to improve further courses. The first interviews were conducted before the course started and the post interviews were held one to two years after the course. The interviews were semi-structured, guided interviews with longer narratives about biology classes in the topic ecology and outdoor biology. Hashweh (2005) made clear that planning instruction as well as reflecting lessons elicits teachers´ PCK, therefore those narrative sections about their lessons were important. Previous studies (Keller & Scheuch, 2010a, 2010b; Scheuch & Heidinger, 2009) were conducted to develop the research rationale and the interview guideline. Additionally included were questions of the teacher beliefs interview (Luft & Roehrig, 2007), to make the teachers reason about teaching ecological topics. The teachers were asked to present a teaching sequence they were proud of; the interviewer used questions to highlight every aspect and to get an overall impression of this/these sequence/s.
In total, 23 teachers participated in the course from primary school to upper secondary school. The four volunteers participating in the study were experienced teachers and studied at University of Vienna for lower and upper Secondary Schools called Gymnasium.

Teacher (synonym)	Subjects	Teaching practice (yrs)	Age
Fiona	Biology, Sports	9 (recently came back after maternity leave)	47
Clara	Biology, Zoology	6 (worked as biologist before)	45
Bert	**Biology, French**	**12**	**38**
Anna	**Biology, Religious Education**	**26**	**54**

For this paper we focus on **Anna** and **Bert**, because in their cases self efficacy turned out to be the most important PCK component.

Data Analysis

The data - from interviews as well as from recordings collected during the course - were transcribed verbatim; the latter were working sessions in the afternoon, plenary discussions in the evening, a discussion about reflecting a lesson with the model of PCK itself, course feedback by all participants. The transcripts were coded with deductive PCK categories derived from Park & Oliver (2008). The methodological approach was the qualitative content analysis by Mayring (2010). Each teacher was partly coded by a second person as well – the coding and understanding of the interpretation were discussed until common sense was reached and the blurriness of the applied categories was clarified. Based on this analysis a case study for each teacher was elaborated, reconstructing the teachers' reasoning out of the reported results of the PCK interviews. Those reconstructions include descriptions of the teaching by the teachers including their orientations, aims as well as routines. These reconstructions can be looked at as being the subjective theories of the teachers. In the results of the PCK development only explicit PCK development was considered, which means that the teacher had to make his/her growth explicit and/or the process data helped to identify the progress. Data triangulation with transcripts of process data was conducted for validation of the reported PCK development by the researchers. All other developments, which could also happen easily during almost three years of teaching, were excluded.

RESULTS

In this section the two cases are presented. The results are structured as follows: First their overall subjective theory of teaching their topic; Second the component of self efficacy and connections to other PCK components; Third the PCK development we detected.

Bert

Subjective theory of Bert: The content, in this case ecology, is very important for him. He is fond of good lesson preparation, and further refinement of his lesson plans reflecting the experience is important as well; so he continuously improves his biology classes. He is aware of his students´ interests and tries to include them in his biology class, e.g. he encourages his students to bring interesting phenomena to his class. He works with complex assignments to elicit the understanding of his students – not only to get the grades, but to get feedback about the students' understanding as well. Another focus is the preparation of the students for future written exams in biology at upper secondary levels.

Results from the pre interview: The category of self efficacy occurred in two ways. First, when he looked back at his biography as a novice teacher. In earlier years he easily drew back when there were difficulties by his students in understanding a topic and developed resistance to the teacher and the topic. He avoided the resistance and did not engage in the students´ learning. Later he developed strategies to cope with this problem. The component SE is connected with the KSUS, resulting in a different teaching strategy (KISR) with a curricular argument (KSC). A quotation to illustrate the analysis:"*...for example osmosis. Earlier in my career I taught it and finished it, knowing that not everybody had understood. I didn't want to talk for another three lessons, because I had already told them everything. Now I am converted, I give them more examples; my students make experiments on that topic. That needs more time, but now I know that I can build on that knowledge later on. For example in the context of teaching excretion…."* (pre-§62). Asking for his expectations for the PD course he stated: *"…It is most delicate for a biology teacher to go outdoors; you can easily look like a fool. […] I think that it helps to develop more routine and know more methodological approaches, […], these aspects were neglected in my pre-service education."* (pre-§138). So he wanted to get more SE during the PD course for his future outdoor teaching through learning new strategies and methods (KISR).

Bert planned and conducted a teaching sequence with fieldwork in the first grade of lower secondary level (kids aged 10-11 years) during the PD course. The topics were “seeds and fruits”. The class consisted of high achievers who were expected to complete the lower secondary level in three instead of four years.
Results from the post interview: Bert was more confident in dealing with less favoured topics like plant families, his self efficacy had developed along with a teaching strategy. He gave the students more time to elaborate on a topic: *“With animals it would be easier, but with plants […]. For years I had had the material about common plant families in my drawer and this year I tried to use it. Asteracea, Lamiacea and so on…, and this topic was not received enthusiastically. I had to face resistance for a few lessons, but after some time, when they knew a bit more about it, they liked it. Because then they could identify the most common plant families, they had a feeling of success. My strategy was to start in small portions – each beginning of the lesson one family was presented, for the rest of the lesson we did another topic; for each plant family two of the students prepared a presentation and a poster – the posters stayed in the classroom. Thus they learned it in small doses.”* (post-§72 & 76). Within his fruits project he also connected several PCK components more closely in taking more responsibility for the learning and the interests of the students, with the curriculum in mind and with his confidence that he can build on their special abilities and interests: *“During the project I included other topics as well, which would have come later this year, but the students asked questions about them. For example, photosynthesis and plant morphology to get to the point that they could explain ´Where does the sugar in the rose hip come from?´. Another example is chemical testing for the substances fat, sugar and starch in seeds. This would not be possible with other kids, but with the high achievers I could try it.”* (post-§102).
PCK-development of Bert: His self efficacy was developed and moved into his focus and was also more closely connected with two other components after the PD course: KSUS & KSC! This development was already implicit in the pre-interview, but during the course Bert got to know the PCK model by Park & Oliver (2008), presented by the teacher educators as a grid for reflection on the project: “*As a novice teacher I was tortured to formulate the aims for a lesson - and what happens? You take the whole content and write it down e.g.´ text book p 27-29´. With this [PCK] grid it is not enough to state ´the student has to know what a stone fruit is´, but the aim is something higher-ranking and this is reflected in the six [PCK-] components. You become more conscious about why you teach this topic and in what sequence…*“(PCK discussion-§31). At the end of the post interview he explicitly said that SE is a PCK component which helps him teach biology: *“...some topics are important to me and the curriculum and so I insist on teaching them, I explain to my students’ why I do so and help them to work on them…”* (post-§150).

Anna

Subjective theory of Anna: A good relationship with the students is most important for her, biology content is important as well. Her lesson preparation happens last minute; in her biology class the topic is elaborated in a teacher-student-conversation, where questions and interests of her students are very important. She gives assignments only to grade her students. She likes being a biology teacher very much but she is not satisfied with her preparation style and the stress resulting from her curriculum delay at the end of the school year.
Results from the pre-interview: In the following quotation all the points of Anna’s characterization aggregate: “*At the end of the school year I have to rush through the topics that are necessary for completing the state curriculum. When I tell my students, that I will have to advance fast, they frequently ask me, ´Are you really sure that you will make it? ´.*“ (pre-§52). Self efficacy (SE) is represented in the intense relationship with her students; this is the basis for her teaching and is connected with her perception of her students; her guiding aim is: Students should not lose interest in biology; immediate learning of one topic is less

important for her. Therefore assessment is only done with the purpose of grading: *"Effective testing is done by me only when I have to do it."* (pre-§46). Her answer to the question about a teaching sequence she is really satisfied with was the following: *"It upsets me that I cannot recall any situations that I'm 100% proud of. All I remember is a sequence about spiders in the context of a PD seminar, where I had to work on all aspects during planning, because I had to teach biology in English."* (pre-§12). She mentions that this was nearly a perfect sequence because she was forced to plan ahead, also because the colleagues of the PD course and her headmaster would attend the lesson. In describing the learning of the students in this example she goes into great detail, connecting several PCK components like KSUS, KISR as well as SE. Moreover, assessment (KA) also turned up in an informal way: *„I had enough time to work with a comic I had prepared as an additional activity. The students were asked to identify mistakes and they did not only find the most obvious things, but also details e.g. that the spider was drawn like an insect with three major body parts instead of two. They looked very accurately and I was really satisfied with these results."* (pre-§12). During the PD course she was not able to conduct a project. She just developed material for observing the behaviour of mallard ducks with the focus on behavioural ecology in the tradition of Lorenz (1978). But even this material was only developed because she promised a colleague in the course to do so: *"We built a group [in the PD course] and wanted to develop something in behavioural ecology. We did so by sharing work; therefore I had the moral pressure to deliver the working sheets. Otherwise I would not have made it."* (post-§18).
Results from the post interview: She was not satisfied with a joint curriculum project with chemistry and physics on water quality of a creek in the pre interview and this was still the case in the post interview. She complained about the routine which made this course boring for her and her colleagues: *"You cannot avoid losing your enthusiasm if you present a topic again and again. And this is transferred to your students."* (post-§106). During the PD course we offered a fictitious story about a small hydropower plant to embed our field work at the creek and she claimed that this was a good idea. Once again she stated that she wanted to include this idea, but in the meantime she missed two chances to improve her water curriculum: "*...I want to implement this idea which we had in the PD course. I really liked it, when you embedded the analysis of the creek in this story about the potential for a hydro power plant. We should introduce such ideas; ..."* (post-§100). The PCK component SE was displayed identically in the post interview, all aspects could be reproduced. This is also the case in other aspects, for example, her stress with the lesson preparation: *"... It happens to me in my preparation, that – even when I start planning early – writing down the material is done only last minute."* (post-§50).
PCK development of Anna: In both interviews the SE was very important and her prominent PCK component; It includes the good relationship with her students; the other components are first of all linked to SE. She makes the importance of this component explicit: " *... Efficacy is the most important point for me - what is my mission? Then, the rest of the [PCK] components nearly filled in by themselves and afterwards the connections [between the categories] can also be seen. This is very helpful for planning and reflecting my lesson."* (PCK discussion-§2). This quotation from the PD course reflects her discovery of this component in working with PCK within the PD course. From this category onward she started planning her lesson and was overwhelmed by the result. But in the post interview it turned out that she had not transferred this strategy to her everyday work. She still reports about being dissatisfied with her preparation. Therefore no PCK development could be detected.

DISCUSSION & OUTLOOK

One teacher did develop PCK, the other one did not. Self efficacy played an important role for the development of PCK in these two cases even if it is an antithetic role. Bert, who developed both PCK and stronger connections between the components, planned and conducted a project with self efficacy as an important PCK category for himself in mind. In his case, self efficacy was the trigger to develop the PCK. Bert had already been aware of the changes over the years, reported his self efficacy in the pre interview, and mentioned it explicitly in the post interview, after introducing the PCK concept. This is expressed in the development and the fact that he does no longer suffer from the stress of completing the class curriculum within a year but can work on important concepts, knowing that he can build on them later on (connection between SE, KSUS & KSC). This strong connection was detected only in the post interview and was argued by him in several examples. He took the responsibility for helping the students to learn a topic. This aspect is in line with several authors: The consideration of the KSUS is a clue for developing PCK (e.g. Hashweh, 2005; Van Driel & Berry, 2010; Van Driel, Verloop, & Vos, 1998). Anna, on the other hand, did not conduct a project; therefore no practice with the given topic took place. This also restricted her reflection to the development without the teaching experience. In her case the self efficacy is a central component as well, but it seemed to hinder any development because in relying on her relationship and constructing her instruction around this factor, she had not felt the need to follow new paths. She has an elaborate content knowledge at hand, and therefore does not need a precise lesson plan but can start with a topic right away. As long as this relationship to her students and to the topic is not disturbed (e.g. by curriculum demands or assessment needs) she is very satisfied, also in reaching her personal goal (not loosing interest and some students should decide for a science or medical career) and in meeting the interests of her students. No development could be detected, although she was given matching offers to her self-reported problems.

Therefore we could prove the claim of Park & Oliver (2008) that SE is a central new component of the hexagon model of PCK. But teacher educators have to be aware of the complex interaction between the PCK components and their very different influences on each other. In comparing these two cases, reflected practice was the difference, and therefore provides a hint why Bert developed PCK and Anna did not. Further research on the role of the single PCK components in dependence on each other has to be done – to further develop the PCK model as such as well as to understand the potential for developing PCK in teacher education. One idea about the role of self efficacy is that SE is the antipode of the component teacher's orientation to teaching the subject (OTS). While OTS represents the teacher's beliefs to the school subject and the discipline itself; self efficacy is a kind of moderator component how the teaching is realized. Further research on this question has to be done.

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DEVELOPING NETWORKS TO SUPPORT SCIENCE TEACHERS WORK

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INTRODUCTION

In educational research literature the concept of network has emerged as a strategy to support teachers' professional development (Huberman, 1995; Jackson & Temperley, 2007; Van Driel, Beijaard, & Verloop, 2001). This paper reports on a study about teachers' collaboration in networks on improving the quality of their own teaching practices. These networks exist at the meso-level of the educational system between the micro-realities of teachers' individual practice and the macro-level, where educational policies and intentions in the educational system are formulated. At this level networks provide an organizational frame where individual teachers' private knowledge and the public knowledge in the educational system can mix with the intention of improving teachers practices (Lieberman, 2000). The research question that guided this study is: How can networks provide opportunities for teachers from different schools to collaborate on improving the quality of their own teaching practice?

The context in which these networks were studied was a development project that was co-funded by the Danish Ministry of Education and four municipalities. The aims were to develop collaborative activities in primary science teacher communities in schools and in networks between teachers from different schools in each municipality. Each network were organized and moderated by a municipal science coordinator.

ANALYTICAL FRAMEWORK

The concept of *Network Learning Communities* (Jackson & Temperley, 2007; Lieberman, 2000; Stoll, Bolam, McMahon, Wallace, & Thomas, 2006) was used to analyze possibilities and constraints of network activities that aimed to improve participating teachers' individual practice. A characteristic feature of successful and sustainable networks is that the knowledge base balance between the private knowledge of the teachers and the public knowledge that informs the teachers practice through collaborative activities in the network (Busch & Sølberg, 2004; Jackson & Temperley, 2007; Lieberman, 2000; Lieberman & Wood, 2002).

RATIONALE

A statistical study aimed at, amongst other, estimating the effect of network communities on pupils outcome support the hypothesis that pupils do better in schools where teachers collaborate in networks (Jackson & Temperley, 2007). Similar findings is documented in the German SINUS-project, where pupils from schools participating in the SINUS-programme scored higher in PISA 2003 compared with pupils from schools not participating. A characteristic feature of the activities in SINUS is that communities of teachers from different schools collaborate in clusters about collective activities that aim at improving teacher collaboration, teachers' individual practice and sharing best practice (Ostermeier, Prenzel, & Duit, 2010)

Standard professional development programs are problematic, because they of deliver “one size fits all”-activities that are not easily adaptable to teachers own practice. On the other hand, networks provide the organizational framework that is highly user driven around the interests and needs of the participants (Lieberman, 2000); (Lieberman & McLaughlin, 1992). In their review on strategies to reform science education Van Driel et al (2001) claim that *learning in network* is a powerful strategy to achieve lasting change in teachers’ professional knowledge. Two arguments support this claim. First, experienced teachers’ natural resistance to innovation and change can be reduced by learning in networks. Second, learning in network may be particularly effective, when teachers share similar tasks, but have different experiences performing these tasks in their own school. Coming together to share knowledge provide opportunities for teachers’ to review different practices and develop a shared attitude about best practice.

METHOD

In the present study municipal science coordinators were asked to write narratives about network development in their municipality. This provided the researchers with four different accounts on network development. Their written narratives were then condensed into descriptions of the development of networks at the municipal level that provided information about possibilities and constraints for developing networks. The narratives outlined both activities, interactions between different stakeholders (municipal science coordinators, teachers, other resource persons and the municipality) and the overall progress during the three year time span of the development project. Then the researcher supplemented the narratives with interpretations about what elements that facilitated or constrained the development of networks. To increase validity the narratives with the researchers’ interpretation were the read by the municipal science coordinators and the revised and edited according to their suggestions. The narratives provided rich information about diverse conditions for developing networks. Diversity of the narratives was seen as a quality because of the explorative nature of the study.

In the next step the narratives were analyzed for patterns in elements that facilitated or constrained the development of networks. The first author then asked the municipal science coordinators to co-interpretate the patterns that had emerged in the narratives. Thus the municipal science coordinators contributed to a deeper understanding of elements that facilitated or constrained the network development (Kvale, 2004).

The written narratives were triangulated with two additional sources of information. The participating teachers’ response to a longitudinal survey and the assessment report that each school submitted when the development project ended. These data sources provided information from the teachers’ perspective about their attitude towards teacher-to-teacher collaboration within their own school, in network activities between schools and the municipal support in the networks. The longitudinal survey consisted of a questionnaire that was distributed at the beginning and end of the development project. It contained both closed and open-ended questions. Teachers’ responses to closed questions were subject to a statistical analysis. Differences between their initial and final responses were tested for significant variations by using t-test. The responses to open-ended questions were categorized according to whether the teachers expressed a positive, neutral or negative attitude about teacher-to-teacher collaboration, network activities and municipal support. The assessment reports that each school submitted at the end of the project were collective accounts from the group of teachers participating in the project. The assessment was guided by open-ended questions and the responses were categorized similarly to the individual teachers’ responses to the open-ended questions in the longitudinal survey. For details about these two sources of information see the technical report (Sillasen & Valero, 2011).

RESULTS

The study revealed several elements that facilitated a sustainable development of teachers' collaboration in networks.

One element was the recruitment of an experienced science teacher to guide teachers in their collaborative activities both within the schools and in network activities. For some network groups the guidance of an experienced science teacher was of great value to inspire the teachers on developing new activities.

A second element of the network was the biannual workshops where teachers from different schools came together to engage in collective activities. In one municipality the science coordinator had chosen outdoor education as a common theme for development of teaching activities. In the municipal workshop an external resource person supported the teachers in their collective effort to develop teaching activities using the framework of outdoor education.

A third element of the network was the creation of network groups of particular interest. One example is from a municipality in a rural district with many small schools. In one of the municipal workshops teachers from these small schools met and formed the "rural schools network". In the assessment report from one of these rural schools teachers wrote that "the rural schools network" *was a very fruitful community, because all teachers in the network shared similar conditions and challenges in teaching science.*

A fourth element was the participation of the municipal science coordinators in network formation. The municipal science consultant's participation in network activities was multifunctional. S/he communicated with schools about what their needs are for external support, planned collective activities, invited external actors, organized workshops, applied for funding for network activities, found examples of good practice within the network that could be shared and coordinated local support for schools and network activities. An important personal competence of these municipal science coordinators was to be highly adaptable to the needs and demands of the participating teachers in the network. Their participation at various levels of the network activities was highly valued by the participating teachers.

The study also provided examples of network activities that constrained sustainability of the network. One important element was that the collaborative activities must relate directly to teachers daily practice. Otherwise there was a risk that teachers did not feel obliged to engage in future network activities. A second element was that the network needs a dedicated moderator to coordinate, communicate and recruit teachers to engage in network activities. A third element was that the moderator needs support from the municipality or a local science centre to sustain the network. Otherwise the moderator might feel declined to continue network moderation if the network was not institutionalized.

CONCLUSIONS

The research presented here shows that developing networks provide opportunities for teachers to come together to share knowledge about their individual teaching, to be inspired by external resource persons and to commit to developing new teaching activities in collaboration with teachers from other schools. But the sustainability of these network activities depended strongly on whether the teachers considered the outcome to be useful in their own teaching practice. Second, developing networks is a fragile process that requires commitment from various levels of the educational system (teachers, municipal science coordinators, school leaders and science centers).

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IN-SERVICE SCIENCE TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE CONFIDENCE LEVELS AND VIEWS ABOUT TECHNOLOGY-RICH ENVIRONMENTS

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Abstract: Science teachers need to be able to integrate technology into science teaching. Identifying science teachers' confidence levels in technological pedagogical content knowledge (TPCK) and determining their views about using TRE in science instruction is an important issue since it can reveal if and how they will use TREs. Therefore, this study aims to address challenges faced by in-service science teachers during creating TREs. The data were gathered through the TPCK confidence survey and subsequent interviews. Ninety-five in-service science teachers from public middle schools in Ankara participated in this study. Additionally, interviews were conducted with four voluntary participants. Findings showed that in-service science teachers had a low level of confidence in using technology in science teaching and they stressed that they need professional development for using TRE for effective and meaningful science teaching.

Keywords: Technological Pedagogical Content Knowledge, Teacher Confidence, In-Service Teachers, Technology-Rich Environments

INTRODUCTION

The turn of the 21st century marked the beginning of a much common and widespread use of computer technologies in science classrooms and practically everywhere else because personal computer hardware with even higher capacities became affordable to larger populations and applications with enhanced visual characteristics were created with lesser effort not only by computer experts but also by science educators. Although not sufficient for all teachers, several initiatives and efforts emerged in order to help science teachers to better understand associated teaching methodologies and benefits of Technology-Rich Environments (TRE) in science.

Knowledge of the natural sciences is connected to explain objects, phenomena, and their interactions in the natural world (Lunetta, Hofstein, & Clough, 2007). Therefore, learning about nature should take place through interaction (careful observation, manipulation, and drawing conclusions) with the phenomena and not in an abstract way. The constructivist approach to teaching and learning stresses that learners are not blank slates on which to write freely. Rather they come to the learning environments with all sorts of pre-conceptions and these are often times are not scientifically acceptable. Science teachers as facilitators of learning in classrooms design meaningful learning activities and environments in which students can gradually construct an understanding compatible with the scientifically acceptable ones.

Hence, science instruction should help them "(a) add powerful, durable, and generative examples to their repertoire of ideas; and (b) enable students to grapple with their full repertoire of ideas to form a more coherent perspective on the scientific domain. Technology-

enhanced materials that make scientific thinking visible can play an important role in both processes" (Kali & Linn, 2008).
In the coming years, computing is expected to be increasingly effective and unavoidably necessary in the processes of science as it is expressed in "Towards 2020 Science" report: "Scientists will need to be completely computationally and mathematically literate, and by 2020, it will simply not be possible to do science without such literacy. This therefore has important implications for education policy right now" (The Science Group, 2006, p.8). In an OECD report entitled "21st Century Learning Environments" the role of schools are specified as follows: "Today, ICT skills – from completing a simple search on the Internet and writing an essay in Word, to cutting a video and designing a Web page – are a prerequisite for entry into the workforce. Schools have an important role to play in providing students with the necessary skills to become tomorrow's knowledge workers" (OECD, 2006, p.20). In-service science teachers play an important role in creating successful Technology-Rich Environments (TRE) in science teaching and their TPCK confidence is an effective factor to create technology rich science teaching environments

Science teachers' technological pedagogical content knowledge

Technological pedagogical content knowledge (now known as TPCK or TPACK) has become a commonly referenced conceptual framework of teacher knowledge for technology integration within teacher education. TPCK is described as complex interaction of content, pedagogy and technology and discussion of successful integration of technology into instruction (Koehler & Mishra, 2008). In recent years researchers described TPCK within the framework Shulman's (1987, 1986) description of pedagogical content knowledge (PCK). According to Shulman (1986, p.9) PCK "goes beyond the knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" and PCK is the connection and relation of pedagogy and content knowledge. Researchers conceptualized PCK in the domain of teaching with technology under different schemes: "Margerum-Lays and Marx (2003) referred to PCK of educational technology, Slough and Connell (2006) used the term technological content knowledge, and Mishra and Koehler (2006) suggested the term technological pedagogical content knowledge (TPCK) – a comprehensive term that has prevailed in the literature" (as referred to and cited in Angeli & Valanides, 2009, p.155). TPCK can be described as how teachers understand educational technologies and PCK interacts with technology to produce effective teaching with technology.

Aim of the Study

This study aims to measure in-service science teachers' TPCK confidence and identify their views about using Technology-Rich Environments (TRE) in science and also we aim to address challenges faced by in-service science teachers creating TRE, give suggestions for successful technology integration in science teaching.

Research questions

This study will focus on the following research questions:

I. What are in-service science teachers' confidence levels on four TPCK constructs (i.e., TK, TPK, TCK, TPCK)?
II. What are in-service science teachers' views, needs, and classroom practices about Technology-Rich Environments?

METHODOLOGY

A non-random purposeful sample was used to gather data from in-service science teachers. Ninety-five voluntary public school science teachers participated in this survey. Both quantitative and qualitative research methods were used to investigate the level of TPCK confidence. The TPCK confidence-science instrument has been adapted into Turkish from Graham, Burgoyne, Cantrell, Smith, Clair and Harris (2009). The instrument was sent to more than 450 in-service teachers by e-mail. 101 teachers' completed and returned the survey, but 6 of them were excluded because of missing data. Additionally, face to face semi-structured interviews were conducted with 4 of the participants. Sample characteristics are summarized in Table 1.

Table 1. The characteristics of participants

The characteristics of participants	f	%
Gender		
Female	44	46.3
Male	51	53.7
Teaching hours in a week		
10-14	10	10.5
15-19	35	36.8
20-24	38	40.0
25-19	10	10.5
29-34	2	2.1
Number of Students in teachers' classroom		
Less than 20	10	10.5
Between 21-30	60	63.2
Between 31-40	21	22.1
Between 41-50	4	4.2
Teachers' Professional Experience		
1-5 years	17	17.9
6-10 years	35	36.8
11-15 years	23	24.2
16-20 years	13	13.7
Upper than 21 years	7	7.4

RESULTS and DISCUSSION

To address the question of perceived confidence level of in-service science teachers' related to the four TPCK constructs teachers were asked, "How would you rate your own confidence related to task associated?" Twenty-four items along the areas of technological knowledge, technological pedagogical knowledge, technological content knowledge, and technological pedagogical content knowledge of these areas were asked, and the scale for answering consisted of 5 points of confidence. Means were calculated for all items is showed in table 3 and average mean for four sub-factors is showed in table 4. Table 2 shows the ranges of confidence levels formed.

Table 2. The Ranges Belonging Confidence for Likert Type Scale

Range Value	Confidence Level
1,00–1,79	not confident at all
1,80–2,59	slightly confident
2,60–3,39	somewhat confident
3,40–4,19	fairly confident
4,20–5,00	completely confident

From the responses of teachers' ranges, minimum, maximum and standard deviation are reported for each item. TPCK sub-factor teachers asserted that they feel somewhat confidence in the 6th item "Help students use digital technologies to organize and identify patterns in scientific data", TPK sub-factor they feel somewhat confidence in 4 items "Help students use digital technologies that extend their ability to observe scientific phenomenon", "Help students use digital technologies that allow them to create an0d/or manipulate models of scientific phenomenon", "Use digital technologies to improve communication with students", "Use digital technologies to help in assessing student learning". All items of TCK sub-factor, teachers asserted that they feel somewhat confidence and TK sub-factor “Create and edit a video clip” item they feel somewhat confidence but two items “Use Web 2.0 technologies” and “Create your own website” they feel slightly confidence.

Table 3. Summary of Descriptive Statistics Results for the Question, "How Would You Rate Your Confidence in Doing the Following Tasks Associated With Technology Usage?"

SF	Item	N	Range	Minimum	Maximum	Mean	Std. Deviation
TPCK	4	95	4,00	1,00	5,00	3,66	,918
	5	95	4,00	1,00	5,00	3,42	1,03
	6	95	4,00	1,00	5,00	**2,97**	1,18
TPK	7	95	4,00	1,00	5,00	**3,03**	1,11
	8	95	4,00	1,00	5,00	**2,84**	1,27
	9	95	4,00	1,00	5,00	3,52	1,10
	10	95	4,00	1,00	5,00	**3,14**	1,13
	12	95	3,00	2,00	5,00	3,51	1,03
	13	95	4,00	1,00	5,00	3,76	1,02
	14	95	3,00	2,00	5,00	3,42	,917
	15	95	3,00	2,00	5,00	**3,35**	,921
TCK	16	95	4,00	1,00	5,00	**3,23**	1,04
	17	95	4,00	1,00	5,00	**3,10**	1,18
	18	95	4,00	1,00	5,00	**3,03**	1,19
	19	95	4,00	1,00	5,00	**3,30**	1,04
	20	95	4,00	1,00	5,00	**3,21**	1,08
TK	21	95	3,00	2,00	5,00	3,90	,911
	22	95	3,00	2,00	5,00	4,22	,865
	23	95	3,00	2,00	5,00	3,70	1,20
	24	95	4,00	1,00	5,00	3,96	1,06
	28	95	4,00	1,00	5,00	3,52	1,25
	29	95	4,00	1,00	5,00	**2,77**	1,48
	30	95	4,00	1,00	5,00	**2,10**	1,283
	31	95	4,00	1,00	5,00	**2,25**	1,20

Table 4. Summary of Descriptive Statistics for Sub-factors for the Question, "How Would You Rate Your Confidence in Doing the Following Tasks Associated With Technology Usage?"

				Scale		**Item**	
Sub-Factors	Number of Items	Min.	Max.	Mean	Std. Deviation	Mean	Std. Deviation
TPCK	3	3,00	15,00	10,06	2,77	3.53	.92
TPK	8	12,00	40,00	26,61	7,35	3.25	.92
TCK	5	5,00	25,00	15,88	4,98	3.18	.99
TK	8	12,00	40,00	26,46	7,38	3.31	.92

From the responses of teachers, they asserted that they feel fairly confidence TPCK sub-factor but somewhat confidence TPK, TCK and TK sub-factors. Teachers feel least confidence TCK sub-factor items that mean they cannot use the educational technologies for a specific topic and get difficulties while relating technology and content, in their science instruction. Vice versa, they feel somewhat confidence knowledge about how to use technology and also to teach more effectively with technology, help students meet any specific curriculum content to use technologies appropriately in their learning. “In other words, merely knowing how to use technology is not the same as knowing how to teach with it" (Mishra, & Koehler, 2006). Teachers feel most confidence in their ability when teaching science with technologies (TPCK) (Graham et al, 2009).

The second research question was "What are the in-service science teachers' views, needs, and classroom practices about TRE?" in order to find an answer to this question 5 questions were asked to 95 in-service science teacher and semi-structured interviews were conducted with 4 teacher

Table 5 Descriptive Statistics of Teachers' Views about TRE in Science

Computer facilities	f	%
Computer facilities at the school		
None computer at school	6	6.3
One computer each class	28	29.7
Computer Lab. at school	41	43.2
One computer used for several class	20	21.1
Hours in a week computer-based instruction		
1	17	17.9
2	33	34.7
3	17	17.9
4	11	11.6
More than 4	17	17.9
Group of class in computer-based instruction		
One computer each student	5	5.3
One computer for two students	8	8.4
Small groups	11	11.6
Whole class	71	74.7
Computer based instruction years		
0	10	10.5
1-5	72	75.7
6-10	13	13.8
Need professional development using computer for instruction in science		
Yes	74	77.9
No	21	22.1

Responses to the questions about TRE teachers asserted that computer facilities at their schools are not well enough to create a TRE so they generally give computer-based instruction to whole class and approximately all the teachers need a professional development about how to use the computers in science instruction. There is a need for providing technological pedagogical content knowledge confidence to in-service science teachers in order to create optimally functioning technology enhanced classrooms. Some recent studies focused on the barriers effecting technology integration such as limited access to internet, classroom size, and lack of teachers' knowledge about successful technology integration into instruction (Çakır & Yıldırım, 2009; Cure & Özdener, 2008). Also some other researches indicate that PD program have positive impacts to on teachers' development of TPACK (Guzey & Roehrig, 2009; Graham et al. 2009; Varma, Husic & Linn, 2008) and can help teachers successfully, integrate technology into their practice (Niess, 2005; Harris, Mishra & Koehler, 2009).

Interviews were conducted with 2 male and 2 female science teachers. Four questions were asked in order to understand how they create a TRE in science instruction. The following four questions were asked during the interviews:

i. For what purposes do you use computers in teaching science?
ii. What are the barriers to the TRE in teaching science?
iii. How do you currently use computers to support your science teaching?
iv. How do you create a TRE in science teaching?

Teachers asserted that they use computers for showing animations, simulations, watching videos, films, making representations with power point during their instruction. The barriers to TRE were; no access to internet at schools, difficult to find and do technology rich materials such as animations, simulations, video for every subject, creating TRE needs good planning and preparing before the class, having classroom management problems. Teachers tend to group TRE for whole class and show the animations, simulations, video by the projector. They asserted that they sometimes stop the video or animation and ask questions to the class about the subject. One teacher described current use of computers in his science instruction as follows:

> *I usually use animations or videos form instruction. It is difficult to find visualizations for every subject in science since most science subjects are abstract. I have to spend time and prepare in order to create technology rich science lessons. However, students in my class are highly motivated when I use visualizations in my science teaching. In the last lesson, I used a cartoon animation of blood cells in my class. The whole class watched the animation together and solved a puzzle after the animation. However, sometimes watching a video or animation in a science lesson cannot be different from watching a movie at the cinema.*

Another teacher described her technology rich class as follows:

> *I use a projector when I am using computer in my class. I arrange student's seats in the best way for them to see the whiteboard. I start the lesson with brainstorming about the subject then we watch a video or animation. I do not usually have classroom management problems because students are highly motivated when they are watching a video or animation. However, sometimes students find their peer's questions ridiculous or foolish*.

CONCLUSION

This study shows that in-service science teachers do not have TPCK confidence sufficient to create a TRE in science teaching. They need professional development about how to use TRE in science teaching. Teachers need to have confidence to use technology as enrichment not as a replacement in science teaching. Koch (2005, p.25) emphasizes that technology cannot alone help students learn science. As she explains a computer can become a part of the science learning experience, if the child feels a need to use it in learning and such a need can be created for example while exploring what causes different weather conditions. In this case students can easily access to some weather reports from the Internet. This act makes the computer a useful and meaningful tool in learning. Such use can also be found in many other computer applications (e.g. certain software packages and online resources) that allow students to explore science phenomena in a simulated environment. Access to interactive manipulation of the simulated phenomena, in a way, forms a science laboratory that allows the child to study and learn in her/his convenience. Successfully integrating technology into science education heavily relies on the development of well-built, coherent professional development programs that are designed with a clear understanding of how teachers need to use technology in their class in the most effective way.

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INTEGRATING TECHNOLOGY INTO PRE-SERVICE PHYSICS TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE

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Abstract: New physics teachers should be equipped with competences for successful integration of technology in the classroom. As an extension of Shulman's PCK (Pedagogical Content Knowledge), teachers need to learn how technological tools can transform pedagogical strategies and content representations for teaching specific topics. The paper reports on the integration of selective teacher training materials, which were used through a blended learning course for pre-service physics teachers. Focusing on the development of Technological Pedagogical Content Knowledge (TPACK) the study examines how pre-service teacher candidates used computer-based technology, to enhance their lesson plans, by selecting appropriate technology tools from the course materials of a European funded project and creating learning opportunities for students. The pre-service candidates' questionnaires, lesson plans and reflection journals were sources of data. Data were analyzed, incorporating both quantitative and qualitative techniques, to determine the effectiveness of the course materials and the course design on pre-service physics teachers' development of TPACK. The training materials appear to stimulate pre-service physics teachers' thinking about useful instructional technological strategies and helped in promoting the development of their Technological Pedagogical Content Knowledge. The findings of the study highlight a need for future research on the development of teachers' TPACK.

Keywords: Pre-service physics teachers, computer-based technology, integrating technology, development of TPACK, blended learning course

THEORETICAL BACKGROUND

Research literature on computer-supported learning suggests the consideration of two important aspects. Firstly, due to the diversity of disciplines and unique features of technology, the ways in which technology might best be used for each discipline strongly depend on the content to be taught [3]. Secondly, the extension of Shulman's concept of "pedagogical content knowledge" to "technological pedagogical content knowledge" (TPACK) [7] emphasizes the critical role of the teacher as curriculum designer. It follows that realizing the potential of the technology requires skills not just of technology, pedagogy, and content in isolation but rather of all three taken together. TPACK is primarily achieved when teachers know how technological tools can transform pedagogical strategies and content representations for teaching specific topics [6].

According to the conceptual framework of Sandholtz, Ringstaff & Dwyer [9] teachers have to move through an evolution of thought and practice when learning to use technology in the learning process. They should start in the so-called 'entry-phase' and end up in the 'invention-phase' discovering new uses for technology tools and using technology as a flexible tool in the classroom to facilitate the emergence of new teaching and learning practices. At a typical entry-level, the teacher uses direct instruction and whole class activities to deliver content and skills to the students. In a classroom of a teacher at innovation (or invention)-level, students are engaged in using technology to do things that could not be done without it.

Researchers and practitioners have been seeking reliable and valid ways to measure the constructs associated with the TPACK framework. Harris and her colleagues [4] promote in amendment of published self-report surveys for assessing TPACK an instrument that supports a performance-based evaluation of TPACK, enabling a triangulation of self-report data and external assessments. Their “TPACK-based technology integration assessment rubric” should support teacher educators to more accurately assess the quality of technology integration in their students’ lesson plans by reflecting on four dimensions: Curriculum-based technology use, using technology in teaching/learning, compatibility with curriculum goals & instructional strategies, fit of content, pedagogy and technology together.

RATIONALE

Recent reviews of the effects of ICT in science lessons show that teachers do not yet exploit the creative potential of ICT and do not engage students enough in the production of knowledge [1]. Therefore teachers need training and continuing professional development in the use of ICT to carefully integrate ICT into the teaching process and to provide appropriate guidance [5]. Actually, ICT-rich environments already provide a range of affordances to enable learning of science [11]. Researchers suggest that integrating these affordances with other pedagogical innovations provides even greater potential for enhancement of student learning [2]. Therefore, supporting the professional development of pre-service teachers for technology integration seems to be an important issue for teacher education.

The context of this study was a teacher education course, aiming at helping prospective teachers to develop abilities to integrate technology with content and pedagogy. Teaching materials developed within a European project and adapted for the education method course, covered three different physics topics: “Cooling & change of state”, “basic electricity concepts” and “motion & forces”. For each topic, up to three types of activities, exploiting the use of ICT to stimulate thinking and promote understanding of basic physics concepts, were offered: Data-logging, simulation and modelling.

The purpose of the study was to investigate prospective teachers’ development of TPACK attempting to address two broad questions:

1. Is there a relationship between the perceptions of the learning environment, motivational orientations and the self-reported evolution of TPACK?
2. Are self-reported knowledge gains in TPACK in agreement with external assessment of teachers’ own lesson plan designs?

METHOD

Participants and Setting

The participants of the study included 17 prospective teachers (9 female, 8 male); all were novices in the field of technology integration in physics teaching and learning. The course was designed as blended-learning course lasting 16 weeks throughout a whole semester. For communication and collaboration as well as for the distribution of the training materials and the questionnaires an electronic platform, based on the software Moodle, was used. There were three 4-hour in-class units in the weeks 1, 6 and 10, during which the prospective teachers were offered opportunities to learn from and not about teaching with technology (see table 1). By means of self-study materials, prospective teachers had to work on individual assignments, designing lesson plans for each of the three topics (cooling & change of state, basic electricity concepts, and motion & forces), and deliver them to the instructor. The elearning-part of the course enabled prospective teachers to share and discuss their ideas.

Week	Components	Methodology
1	Class session introducing data-logging activities	The initial class session introduced data-logging activities (analysing motion, free fall, accelerated trolley, rebounding trolley and current and voltage for a tungsten bulb) with opportunities for practical work resulting in collecting data.
2 - 5	Individual assignments using on-line resources for video and data-logging	In the succeeding weeks students worked autonomously, obtaining the module and software resources through the *Moodle Virtual Learning Environment (*VLE). Through self-study, students learned to analyse video capture data and then chose a topic for which they were required to design a lesson plan featuring the use of video measurement or data-logging.
6	Class session introducing modelling activities	In the second class session, students were introduced to modelling activities featuring the same topics as the first data-logging session.
7 - 9	Individual assignments using on-line resources for modelling	During weeks 7 to 9, students engaged in a further self-study assignment concluding with designing another lesson plan on a chosen topic. This time students were also expected to communicate with each other through the forum within the VLE, exchanging ideas and comments on each other lesson designs.
10	Class session	The third class session introduced simulation activities from the chosen modules.
11 - 14	Individual assignments	During the next weeks of self-study, students engaged in a third lesson design assignment on a chosen topic, exchanging ideas through the VLE forum as previously.
15 - 16	On-line discussion	In the final two weeks students were required to use the VLE forum to discuss with colleagues the potential learning benefits of integrating the ICT activities into physics teaching.

Table 1. Components and methodology of the course

Data Sources

The scales and items for assessing prospective teachers' motivational orientations and their perceptions in TPACK domains were primarily drawn from literature [8; 10] and accordingly adapted. A motivation questionnaire was administered in week 1, whereas a TPACK questionnaire was completed twice, as initial one and at the end of the semester. Additionally each of the participants of the study prepared a reflective journal on the overall process of the course at the end of the semester as well as three lesson plans at specified dates.

Data Analysis

Responses from the TPACK questionnaire were analyzed as matched-pair means for each survey question. The quality of technology integration was assessed by means of the

Technology Integration Assessment Rubric (see figure 1), which is based on the frameworks of Sandholtz and Harris and their colleagues [4, 9].

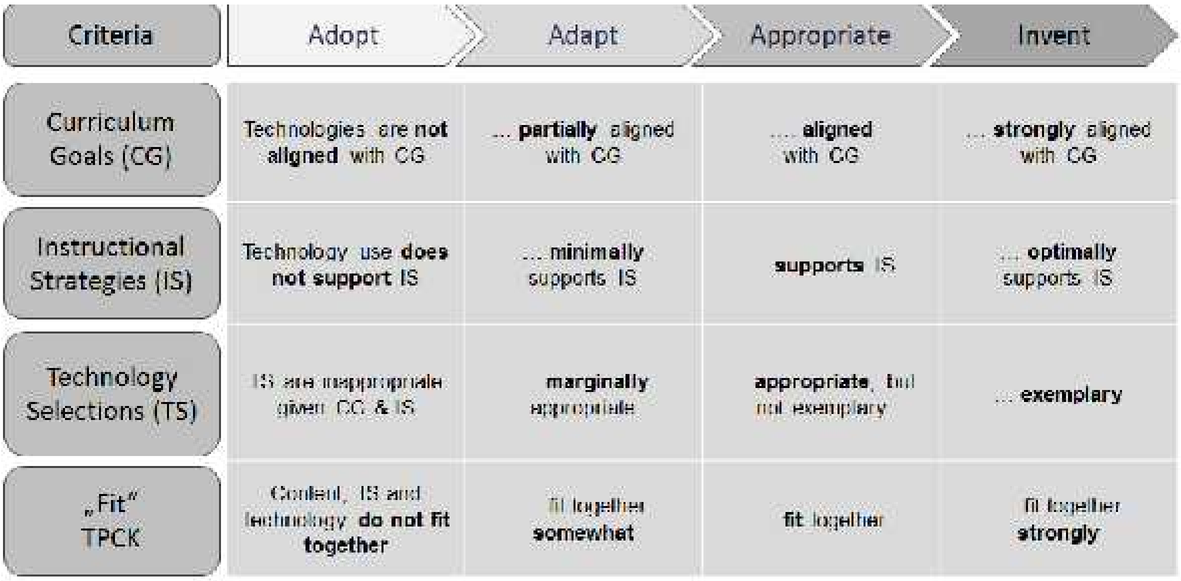

Figure 1. Technology Integration Assessment Rubric[1]

Also, the relationship among motivational orientations, perceived TPACK and pre-post-difference as well as the quality of TPACK inferred from the lesson plans was analyzed. As the primary method of data examination for the reflective journals and the open questions verbal inductive analysis was used. Accordingly, the data were assigned to four categories, resulting in a numerical overview of the outcomes. All items of the questionnaires were aligned on a Likert scale, ranging from 1, "I totally disagree" to 4, "I totally agree".
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RESULTS

The findings of the study indicated that prospective teachers value the course materials as well as the design of the course to be helpful for developing a critical understanding of TPACK, independently from gender and motivational orientations. Prospective teachers' goals and value beliefs for the course seem to have a positive impact on the evolution of TPACK, both inferred from self-reports and the external assessment of the associated lesson plans.

A cluster analysis (see figure 2 and table 2) of the motivational scales shows that the participants of the study can be arranged to three groups: 29% (CL1) report high estimates for goal orientation, content task value, self-efficacy, and control of learning beliefs. Whereas

[1] Based on the conceptual frameworks of Sandholtz and Harris and their colleagues

47% of the students in CL 3 are confident in their abilities for accomplishing and performing the future tasks an report rather high values for control of learning beliefs, they are not so highly intrinsically, but more extrinsically, motivated and additionally, not convinced about the importance and usefulness of the course.

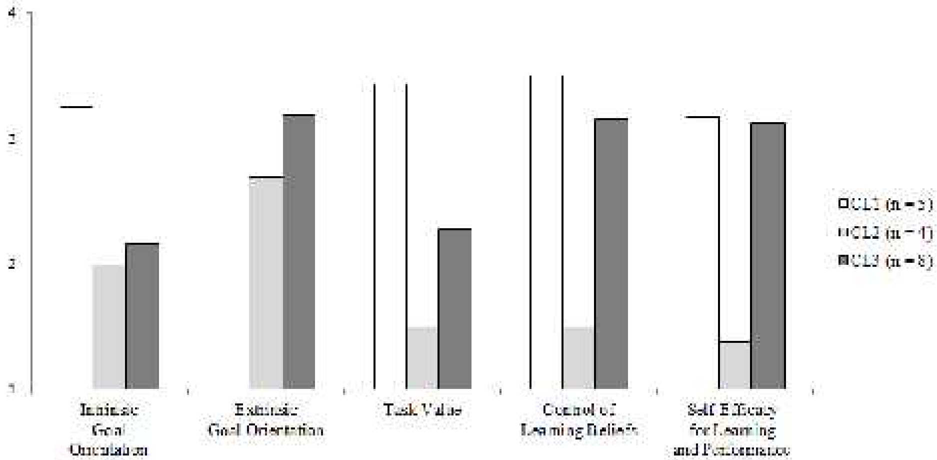

Figure 2. Motivational orientations of the pre-service teachers

24% of the students in CL2 can be described as students with motivational strategies clearly underneath the mean. They report considerable low estimates for their task value, their control of learning beliefs, and their self-efficacy for learning and performance. Furthermore, their ratings for intrinsic as well as extrinsic motivation are also significantly lower than the reference values of group CL3.

	M_{CL1}	SD_{CL1}	M_{CL2}	SD_{CL2}	M_{CL3}	SD_{CL3}
Intrinsic goal orientation	3.25	0,53	2.00	0.88	2.16	0.82
Self- efficacy for learning and performance	3.18	0.09	1.38	0.00	3.13	0.93
Content task value	3.43	0.17	1.50	0.00	2.27	0.94
Number of students	5		4		8	

Table 2. Descriptive statistics of motivational strategies

As illustrated in figure 3, there is also a relationship between motivational orientations and evolution of TPACK. The grey bars in figure 2 correspond to the pre-post-differences of perceived TPACK; the white bars represent the quality of technology integration derived from the lesson plans. The values illustrate the level reached in percentages of the maximum, related to four on the used Likert scales. For example, students in CL1 estimated their TPACK increase to 73% of the maximum and the quality of their lesson plans were rated to reach 67% of the maximum.

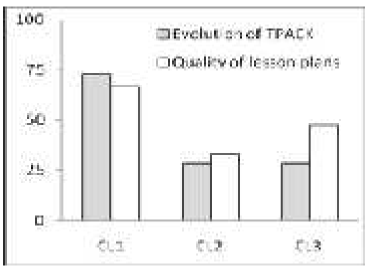

Figure 3: Evolution of TPACK

In addition, ANOVA (see table 3) shows that there is also a significant difference between the groups' mean scores concerning the quality of the corresponding lesson plans (F value = 10.399, significance value = 0.002). For example, students in CL1 attain 14 points on average out of a maximum of 16 points for their third lesson plans, whereas students from group 2 only reach a mean score of 6 points.

ONEWAY ANOVA

Mean Level of TPCK evolution					
	Sum of squares	df	Mean Square	F	Sig.
Between Groups	160.809	2	80.404	10.399	.002
Within Groups	108.250	14	7.732		
Total	269.059	16			

Table 3. ANOVA for the relationship 'affiliation to a certain cluster and quality of lesson plans'

CONCLUSIONS AND IMPLICATIONS

In conclusion, this study provides empirical evidence about the impact of the training materials and the course design on prospective teachers' TPACK in particular topics of physics subject matter. Thereby, the development of TPACK is closely related to the motivational orientations of the pre-service teachers. In consequence, it appears reasonable to focus both on issues to motivate pre-service teachers and on certain content topics for highlighting the pedagogical value of the specific use of technologies for understanding physics concepts.

In order to make future teachers capable to attach importance to their crucial role in the learning process of students, especially when ICT tools are introduced, the need for reinterpreting this role becomes an essential demand in teacher preparation programmes aimed at promoting the use of ICT. To provide vision of, how the teacher's role can influence the successful outcome of ICT activities in science education, should be a chief rationale of educational technology training courses. Indeed, before examining the principles underpinning the teacher's role, it is appropriate to review the potential learning benefits associated with the four software tools which serve constructional activities in physics: data-logging, modelling, simulation and video measurement.

However, there is a clear need for future research on how to best design teacher education programs in preparing future educators for the challenge of teaching in the 21st century. Teacher education programs should certainly focus on developing TPACK to enable teachers firstly, to identify their crucial role in using educational technologies in the classroom, and secondarily, to design computer-assisted learning activities which offer guidance as well as room for individual exploration. The teacher's role is critical in structuring tasks and interventions in ways which prompt pupils using ICT to think about underlying concepts and relationships and to find the right way of instruction and level of complexity. Therefore, future research programs should be aimed at both developing teachers' TPACK and evaluating teacher training programs by observing classroom activities and assessing student outcomes.

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PART 14: EARLY YEARS SCIENCE EDUCATION

Co-editors: *Costas Constantinou and Jane Johnston*

Emergent science, science pedagogy and learning in the early years, cognitive resources for science learning, early years science and technology curriculum, innovative teaching practices in the early years, children's learning, preschool science, early years teacher education in science.

This part corresponds to strand 14. It contains 9 papers.

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EARLY YEARS SCIENCE EDUCATION

INTRODUCTION

In recent years early years science has emerged as a serious research focus in the science educational research community. This has occurred as a result of two paradigm shifts in science education. The first is a shift from a focus on the science – the concepts and skills of scientific inquiry, to greater focus on education – the pedagogical approaches that support scientific and holistic development. The second is a shift from a 'top down' to a 'bottom up' approach, with increasing recognition that early years science, that is, science for young children aged between birth and 8 years of age, is the foundation of all later development and is not well understood. In the European Science Education Research Association (ESERA) this has resulted in an increase of research papers focusing on early years and in 2011 the first Early Years strand. The papers in this chapter are the result of this and exemplify the variety and depth of research in early years science, both within Europe and further afield.

Despite the variety of research that is being undertaken in early years science, there are some common themes emerging in this collection of papers, which illustrate the current issues taxing early years professionals. Making science relevant and motivating for young children in science permeates all papers and indicates the dilemma that may educationalists face, whatever the age of the pupils; that is how to relate scientific conceptual learning to the everyday lives of children. There are a number of ways this is achieved in the papers. Story as a motivational force is a strong theme in four papers. In the early years, the link between the abstract and difficult concepts the teachers is hoping the children will learn can be achieved through the bridge between scientific knowledge and fiction. Other motivational forces are recognised as animals by Gkouskou and Koliopoulos who further look at the most effective pedagogical approaches to ensure that museum educational activities have a positive impact.

In the research involving story another common theme is the use of dialogue to discuss the scientific ideas in the fiction. This is another big issue in early years settings and is a theme also picked up by Kallery in her paper and she further identifies the importance of dialogue with peers. This type of dialogue enables children and teachers to learn together and is not cognitively restricting. The importance of pedagogical and assessment approaches that include elements of dialogic teaching are becoming increasingly recognised by early years professionals and this is another common theme between papers.

Overall, the papers cover a cross section of the issues that early years professionals face in teaching and supporting development in science with young children and the papers therefore are a useful and interesting contribution to the knowledge about young children's emergent scientific development.

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CHARACTERIZATION OF THE BELIEFS OF PRESCHOOL TEACHERS ABOUT SCIENCES

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Abstract: This work is part of the research FONDECYT Project 11100402 "Beliefs of Preschool Teachers Regarding Science, Science Teaching and Learning and their Influence on the Implementation of the Program YOUR COMPETENCES IN SCIENCES (YCS, TCC for its acronym in Spanish)" The purpose of this research is to identify and charaterize the beliefs of 61 preeschool teachers about sciences, its teaching and learning, to then study their development and influence in teacher's practices. The data were collected from an inventory of teachers' pedagogical and scientific beliefs (Porlán, 1997). Preliminary results show a relationship between the teachers' beliefs and certain science teaching-learning models of the teachers.

Keywords: beliefs, science teaching, preeschool education

BACKGROUND, FRAMEWORK, AND PURPOSE.

Belief and behavior appear frequently associated, and a great part of the definitions have in common that *beliefs* guide the thinking and action of people in an conscious and unconscious way and the individual accepts it as truth, and, consequently, it has an influence on in the emotional commitment, even more, it works as a guide for thinking, behavior, or attitude (Borg, 2001). The interest for beliefs lies in the fact that behind a teaching professional practice there is a belief or philosophy (Thom, 1973). A teacher is a reflexive, rational and decision-maker subject, he or she gives opinions, has beliefs and creates his or her own professional development routines, which has to lead indentify the proffesional knowledge of the science teachers and their epistemology to transform the curriculum and train science teachers (Perafán, 2005). This interest dates from the latest 80's, with studies focused on the image of science (Lederman, 1992, 2007), exploration of the concept of science (Porlán, 2004), learning (Aguirre, 1995), and curriculum (Porlán, 2004). Teachers' beliefs would reflect on their behavior or the attitude they show when facing their professional practice, and in this sense the theories of an elementary school teacher regarding science, teaching and learning have a great part in determining the scientific education a child gets. Referring to the same, Levitt (Levitt, 2001) says about preschool teachers that their belief systems are a main and determining factor of the decisions they made about their classes. From another perspective, McCarty et al (2001) reveal that educators whose classes were lower-quality were more likely to answer positively when suggested they had inappropriate practices that teachers with better-quality classes.

In Chile, there are great efforts to improve science education, for example, programs like "Your Competences in Sciences" (YCS, TCC for its acronym in Spanish) is an EXPLORA Program iniciative (http://www.tccexplora.cl/) that through informal workshops, seeks for the development and implementation of formative translation of science competences created for all-level students. Regarding the implementation of these workshops, the objective of the project is to identify the beliefs about science, teaching and learning in preschool teachers of the V Region of Valparaiso, and also, to determine to what extent they have influence on the implementation of their own model of science and the scientific activity it promotes (YCS). Nonetheless, in our country there are little empirical studies about sciences mentioned subject.

Rationale.

Research on the area suggests that this has to be conducted during the course of the class in order to be able to inquiry about which are the beliefs that are most influential on teaching (Lederman, 1992). Some preschool teachers may feel uncomfortable with their knowledge level about science contents, as a result, they may limit the role of science in the classroom (Diffily, 2001). As YCS is targeted to the development and implementation of the competences in sciences set for prescool students, we wonder which beliefs about science, teaching and learning science teachers have and what is the relationship they may have with the teachers' science teaching-learning models. The importance of the project has to due with the high spread and impact the YCS program has, this is why it is so important to know to what extent they have influence on the scientific activity's implementation fostered by YCS.

METHODS.

This study is part of a bigger one that follows a multimodal o mixed process (Hernández, 2006), which involves the complement between the application of a dominant qualitative strategy and elements of a specific quantitative design. In this context, the following is done: a) a qualitative approximation to the studied phenomenon, through description, systematization, and analysis of teachers' beliefs, distinctive elements in their practices, experiences and episodes considered significative to their experience in the YCS program, and b) gathering of information using instruments (questionnaries). Sixty one teachers from three different schools, teaching in three municipalities of Valparaíso constitute the sample for the study. The questionnaire is composed by 56 items distributed in four dimensions formulated as statements and organized randomly, in Likert's format, each of them had four possible answers: Completely agree (4), Partially agree (3), Partially disagree (2) and Completely disagree (1). For this publication we present the questionnaire's results, and we are leaving for a subsequent publication the rest of the aspects that have been mentioned in the text. Microsoft Excel 2003 was used for statistical analysis, which had a moderate rationalist epistemological approach.

RESULTS.

In table N° 1, the teacher's preferences respect to the 56 items of the questionnaire are examined, their answers are presented in averages ($\geq 3,0$) and deviation ($\leq 0,9$). Based on the data it can be inferred that for educators, science is an activity socially and historically conditioned, conducted by scientists that have different strategies which cover processes of intelectual creation, empiric validation, and critical selection; with them a temporary, relative and changing knowledge is built. According to this and in congruence with other work (Porlán, 2004) the level of formulation of science image seen fits more alternative approaches. (40 %). The results show three tendencies: a) a traditional model, focused on verbal transmission, b) technological, focused on the objectives as axes of the practice and reference points to evaluate the students' learning, and c) alternative, when the complex character of the student's engagement and the teacher's role needs to be highlighted (46%). The beliefs about science learning from the sample constituted by teachers presented diverse approaches; a set of declarations near to the idea of learning by building of meaning was detected (58%), without absolute and terminal reference points that have to be reached necessarily.

Dimension	Factor	x	σ	*i*	*f%*
Image of Science	Racionalism	3,4	0,6	32/61	27
	Empirism	3,5	0,5	38/61	33
	Alternative	3,7	0,3	46/61	40
Didactic Model	Traditional	3,3	0,7	23/61	20
	Technological	3,6	0,5	40/61	34
	Alternative	3,8	0,3	53/61	46
Theory of Learning	Formal	3,2	0,8	15/61	16
	Construction	3,4	0,6	26/61	58
	Assimilation	3,9	0,1	58/61	26

Table 1: Interpretation of obtained factors (INPECIP).

Finally, Table 2 shows us a summary of the beliefs about concrete conceptual field teaching. Here, a 59% of the teachers presents an hybrid teaching model. In this sense, we assume that the polled ones have a traditional epistemological-dogmatic notion, characterized by a racionalist image of science, with an academic, traditional teaching model that pretends to own the true, definitive and unquestionable meanings and knowledge, and, on the other hand, the existance of constructivist and evolutive rationalities. Nonetheless, we consider there is a lack of evidence to affirm these ideas..

Dimension	Factor	%
Teaching Model	Hybrid	59
	Not determined	41
	Determined	0

Table 2. Interpretation of beliefs about teaching

CONCLUSIONS AND IMPLICATIONS.

From the analysis of the main components of a set of declarations of ITPSB (Inventary of teachers' pedagogical and scientific beliefs, Liker-type questionnaire, IMPECIP for its acronym in Spanish) a series of factors obtained were organized in four hypothetical tendencies. Regarding the image of science, the teachers do not show a clear tendency. An explanation to this might be that they lack of knowledge or constructs about the subject in particular, but that is not necessarily a priority for this level. For beliefs about teaching and evaluation, a more alternative position can be seen; the reason could be a better command of knowledge about the new learning theories that are not specifically related to science. In preliminary results most of the teachers have an hybrid teaching and leaning model, this mixture is directly related to the diversity of epistemological and pedagogical beliefs that each of them has according to their experience, continued training, pre-service training, and finally, a result of this would be their professional practice. These results are the basis for the next work stages, which are linked to the follow-up process during the implementation of the YCS workshops.

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INQUIRY-BASED ANALYSIS OF EARLY YEARS CHILDREN BOOKS: DEVELOPING SKILLS FOR LATER SCIENCE EDUCATION

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Abstract: Distinguishing fact from fiction is a key feature of science. We investigate the use of children literature to develop this ability among 4-6 year old pupils. To this effect, we chose a children book where special laws, different from real-world natural laws, govern the fiction. Eight teachers were trained to teach a specially designed inquiry based teaching sequence. During the sequence, the children built a real-world device (well and pulley) of which the narration can be considered a literary model. They were then brought to compare the predictions of the model with their observations, and to comment on the contradictions. It appears that children can easily be brought to cross the gap between a literary fiction and a real-world experiment, and to awarely use the results of the latter to confront the predictions of the former.

Keywords: Modelling. Children literature. Experimental verification. IBSE. Impossibility.

INTRODUCTION

While inquiry-based science education has been since 2002 the recommended method in France for introducing very young children to science, it seldom gets beyond "discovery of the world" practices. Classical activities at the kindergarten level (*école maternelle*) are discovery of the five senses, plantation of seeds, actions on materials (making apple juice, dissolution…) (M.E.N., 2005; B.O.E.N., 2008). Such activities are usually intended to give the children a first impression of basic scientific methodology, mostly by insisting whenever practicable to implement the sequence: Proposition of an idea / Test / Conclusion (Coquidé & Giordan, 1997; N.R.C., 2005).

Yet, very young children can be also introduced to other skills involved in science education. We will focus here on those called on by the utilisation of models — namely, the skill to navigate between the real world and a model in order to test the predictions of the latter.

DISTINGUISHING FACT FROM FICTION

This skill is a key feature of science. Nevertheless, whereas the distinction between fiction (usually simplified models) and reality is obvious enough to remain mostly implicit among scientists, it constitutes a challenge for children. Before it becomes a pattern of thought, it has to be internalized, thus calling for explicit teaching (Etkina & al., 2010; Tiberghien, 2009).

While formal models, often involving mathematical representations, are commonplace in professional science as well as, to a certain extend, in high school, they are obviously irrelevant as far as very young children are concerned. To a lesser extend, the same can be said of analogical models (e.g. a polystyrene ball representing the Earth). Stories being a major tool in kindergarten, literary models, seldom used in more advanced scientific contexts, are in fact likely to constitute the first contact of young children with the concept of modelling.

Biology is a favourite subject (Lamap, 2006), but some stories can also be used to work on elementary physics. Even very young children can detect their most blatant imaginary aspects: real-world animals don’t talk and don’t wear clothes etc. Literary fictions are identified as special worlds; they can nevertheless be used to generate questions pertaining to science since “the fiction’s dominant, albeit unsaid, reference is the real world governed by natural laws” (Bruguière & al., 2007).

But can very young children also acknowledge the fact that special laws, different from real-world natural laws, may govern a given fiction? How do they react to such a dissonance? Do they show ability to switch explicitly from one world to the other?

METHODOLOGY

In order to investigate these abilities among 4-6 year old children, we have developed a complete inquiry based sequence around one of the most popular children books in French kindergarten, namely *Plouf !* by Philippe Corentin (Corentin, 2003; Blanquet, 2010; Soudani & al. 2011). Besides the usual literary conventions of such fantasy (talking animals, etc.), the storyline involves an internal contradiction if the diegetic “physics” is to be considered equivalent to real-world physics. During the sequence, the children elaborate a real-world experiment of which the narration can be considered a literary model (Blanquet & Picholle, 2011). They are then brought to compare predictions of the model with observations of a controlled experiment, and to comment on the contradictions.

Eight teachers were specifically prepared to teach this sequence. In France, kindergarten pupils usually work in small groups (4-6 children), the teacher dealing in turn with each group while the others work autonomously. Two devices were used in order to evaluate the appropriation of the sequence by the children. On the first hand, four teachers were involved with their classes in a festive science event (Blanquet, 2009); ten teams of three pupils were directly observed while hosting for other pupils a workshop based on a simpler — but still inquiry based — version of the sequence they had beforehand discovered in the classroom. On the other hand, one senior teacher and three teachers in training and their pupils have been audio- and video-taped (Visa, 2008) while making their way into the sequence. The exchanges between the teacher and small groups were then transcribed and analyzed and the children were later interviewed by pairs.

MAINLINE OF THE *PLOUF !* TEACHING SEQUENCE

The story revolves around a well and a pulley. A hungry wolf falls into a well, thinking there is cheese at the bottom; using a pulley, a pig helps him out, while descending himself down the well; then, a family of rabbits helps the pig out by the same device; ultimately, the wolf helps the rabbits out and gets himself down the well again, still using the pulley. After reading the story, the teacher verifies the good understanding of its different steps through questions and small-groups activities.

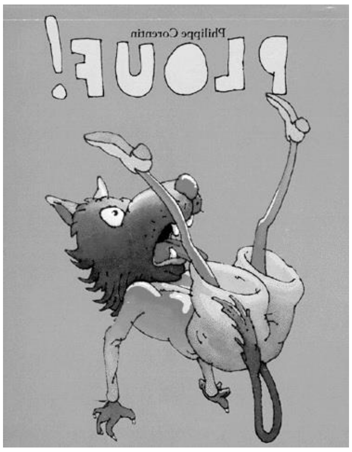

Fig.1: *Plouf!*

Fig.2: *Plouf!* well and pulley device

The sequence then brings children to conceive and build a real-world well-and-pulley device. First, the teacher proposes activities to help pupils to establish the analogy between the book's device and the ones they are going to build. Once it is operational, they are asked to reproduce the different steps of the story, using bottles of various weights with glued images of the imaginary animals on it (Fig. 3). The last step of the story proves impossible to reproduce, since the previous ones imply that the wolf-bottle is lighter than the "rabbits" one [1].

Exchanges among children and with the teacher yield an emphasis on the difference between what happens in the story and with the real-world device. The contradiction is then discussed in the group of children and with the teacher. The children's propositions around it (changing the weight of animals etc.) are implemented. The sequence is eventually re-done and different kind of well-and-pulley devices proposed, with a back and forth alternation between the story and the real-world devices, between prediction of behaviours and their experimental verification.

Fig. 3: Real-world well-and-pulley device

Fig.4: 5 years old hosting a science event: *You try it!*

APPROPRIATION OF THE TWO-WORLD CONCEPT

While (thoroughly enjoyed) repeated readings and real-world experiments were usually needed in the classroom to bring the children to notice the different behaviours of the fictional and real-world devices, they did not appear to be confused by different laws being involved in the two distinct worlds once these difference had been acknowledged. Although specific to this special story (as opposed to classical fantasy conventions), the fictional laws governing well-and-pulley devices in *Plouf!* were accepted as "non-real", apparently without any loss of pleasure in subsequent readings, much to the contrary.

The guidance from the teacher during these inquiry-based learning sequences made it difficult to decide whether the children did, or not, understand the relationship between the two worlds, and the interest of navigating between them. It appeared more clearly during the interviews and the scientific manifestation, free from adult interference. Children were using in context the same kind of questions to their young visitors that the teacher had done previously with them. Typically, after their rendition of the story, they were eager to ask "Can you do as in the story?" (*Est-ce que tu peux faire comme dans l'histoire?*) Furthermore, we observed regulation of the sequence by other children-hosts, on the abstract level. As a host would try and omit the question, another would stop him, insisting that "First, you must ask if he can do as in the story" before explaining "what is the well and what is the pulley" (*il faut d'abord lui montrer ce qui est comme le puits et ce qui est la poulie*) before "doing things" and, then only, acknowledging the impossibility of the last step. The exchanges between hosts clearly established their ability to navigate between the real world and a model, and the understanding of its basic utility. (It nevertheless seems dubious that this achievement was transmitted to their young visitors. The basic educational goal of the event was reached just the same, since all children thoroughly enjoyed themselves while "doing science").

CONCLUSION

It thus appears that 4-6 y.o. children can easily be brought to cross the gap between a literary fiction and a real-world experiment, and to awarely use the results of the latter to confront the predictions of the former. The nature of this skill is essentially the same that they will later need to confront analogical or mathematical models to scientific experiments. Further studies would be needed to establish whether of not the acquisition and consolidation of this skill in early year science education might improve later performance in learning science.

NOTE

1. It should be noted that, while many sequences using this album with young children are available on the French Internet, hardly any of them makes any mention of this impossibility. Do teachers notice it? The question remains open, but the author of the book received only a couple of letters addressing the problem, among hundreds over two decades (Corentin, 2011). Teachers don't usually question the physics of a story.

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FICTIONAL STORYBOOK AS A SCIENTIFIC AND EPISTEMOLOGICAL QUESTION-BUILDING TOOL FOR PRIMARY SCHOOL

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Abstract: This work is focused on a specific type of children's storybook literature, specifically realistic works of fiction, in which the plot reflects laws of nature. This paper explores two storybooks : *Fish is fish* by L. Lionni and *The Promise* by J. Willis et T. Ross. These two stories express implicitly notions of biological development. An analysis of the fiction and the non-ficiton, which exists in these storybooks, allows us to explore how the story's intrigue as well as certain problematic wording can constitute a starting point for scientific as well as epistemological research on the development of living things.

Keywords: Fictional storybook, possible world, problematic process, biological phenomena

INTRODUCTION

The direction taken by the French curricula for Elementary Schools in recent years (2008), which now prioritize 'speaking, reading and writing' across the disciplines, has opened up new opportunities for science-teaching at this level. While this orientation has led to an increased number of readings of informational books, it is less common to use fictional storybooks.
In a previous publication (Bruguière and all, 2007) we showed the potential effects on pupils learning of storybooks, leading to an interrogation of a scientific and epistemological nature. Here, we will focus this reflection on the functioning to the relationship between real and possible worlds in two unusual fictional storybooks: *fish is fish*, (Lionni, 1970 translated in French 1981) and *the tadpole promise (*Willis and Ross, translated in French 2005) in which the plot is based on the different physical changes which each character experiences. The aim of our research is to identify the role of fictional storybooks in scientific and epistemological question-building. The view of science taken in this study is one that emphasizes an investigative nature and the desire to broadly view the contexts for investigation, as noted by the Yager's definition, cited by Butzow (1998) : "*Anything that promote explanations, encourages the creation of explanations, or calls for verification and validation is scien*ce". Furthermore we see with Canguilhem, (1965) that « *Knowing is not so much about knocking up against reality as validating a possibility by making it necessary. In this case, the origins of a possibility are as important as the demonstration of a necessity*. »

BACKGROUND

In reference to possible worlds semantics of Hintikka (1989) considers that there is no break between the possible and real, we are in a more epistemological proximity between science and the story in a report of opposition. For Hintikka, the fiction of possible worlds built on the basis of a real world or a possible world which may or may not occur and towards which we can distinguish between two epistemic attitudes: one on the mode of belief or another mode of knowledge. If knowledge is true by definition relates only to the real world, the belief can be true or false but Hintikka false belief is not at all a negative because it opens the possibility of coming true in a world alternative. We can appreciate the scope of the heuristic fiction by creating all possible worlds helps to get students of the register of belief in the register of knowledge, and develop in them a critical epistemic attitude, which is the issue of the science education. The posture of Hintikka cannot be described as Bachelard in the sense that there is no rupture between common knowledge and rational knowledge. In the same way Bruner (2002) thinks, "When we invent possible worlds of fiction, we can never really leave the world which we are familiar." Bruner (2002) postulates an effect of fiction on the construction of a rational relation to reality. This epistemological position opposed to that of Popper (1985) for whom the stories are fiction out of science, do not belong to the same world.

Children 's literature may be playing an increased role in science classrooms. Nevertheless, most studies have found many inaccuracies in science trade book and have highlighted the need for teachers to carefully select appropriate trade books for classroom use (Rice 2002). To assist in this process, several checklists of books included the identification of inaccuracies have been created (Rice, 2002). For example, Schussler (2008) critically analyses numerous science trade books and asses the information they contain about plant reproduction. In theses studies the sample of children's books include fictional storybooks, narrative and non-narrative informational texts. However, the fictional storybooks aren't in keeping with the same plane in relation to scientific validity. In the fictional story, we cannot consider elements like false but like plausible or possible. The interest of our study lies in focusing on the fictional storybooks for there has not been much research in this field. In this way, Butzow (1998) estimate that fictional storybooks can be used to keep alive this sense of wonder and can become a vehicle through which science is learned. As Bruner (1996) or Ogborn and Millar (1998) said about a similarity between narrative and scientific explanation, we make the hypothesis that the plot structuring for the story is also structuring to generate scientific and epistemological questions. In the context of didactic studies (Butzow and all, 1998) which takes the articulation between reading and writing as a necessary condition for the process of conceptualisation, we hypothesize that the use of fiction will improve the comprehension of the real for primary-school children. Thus, the illustrations and texts cannot be interpreted without interrogating the real objects to which they refer but from which they are differentiated in perceptive and conceptual terms. We will see how this narration is not a mere fictional story having no relationship to the realities of animal life, but instead uses animals so to impart knowledge to the reader about how animals truly live, act and behave in nature. This provokes the reader to reexamine his previous understanding of nature, while at the same time encourages him to develop his knowledge even further.

RESEARCH QUESTION AND HYPOTHESIS

In this background, we think that fictional storybooks present a learning opportunity that cannot be obtained through the use of traditional textbooks. Fictional storybooks create many possible worlds that are not completely unrealistic and have links to the real world.

Our global aim is to identify the role of fictional storybooks in scientific and epistemological question-building. More precisely we propose to study in our communication one of the narrative functions , the role of fictional narrative in the problematic process.

The problematic process will be explored according to two levels : a global level, around the structure of the plot and a more local level, around specific wording. Indeed the story books presents a « golden sentence » at the heart of the intrigue (Tompkins, 2003) which represents the message of the storybook. The repetition of this wording throughout the course of the story takes on multiple meanings in a storybook that can be problematic.

In this way we consider two hypothesis in the problematic process :

- The plot structuring for the story is also structuring to generate problematic questions.

In others words, the story presents a fictional problem, which corresponds to a scientific problem.

- The diffents meanings taken by a wording (title or term) throughout the story generate problematic questions

METHOD

Our case study compares two fictional storybooks: « Fish is Fish » (Lionni, 1970 translated to French in 1981) and « The Tadpole Promise » (Willis and Ross, 2003 translated to French in 2005). These books were selected for the three following didactic reasons:

- They have yet been chosen by science education researchers as examples that promote an integrated approach (Butsow, 1998, Avel and Lanoizelé, 2008);
- They offer a story related to science, but this story is not expressed in scientific terminology. The narrative glues together the fiction and the real world and presents them at a level of accessibility that is appropriate for the child;
- Their plot is based on biological phenomena, in other words, on the different physical changes which each character experiences. More, the plot is based on the same disruptive event, the same incident : the occurrence of hind footed to the tadpole.

For this study, we will examine on one hand the development of the plot, from its beginning to its outcome. Using the Larivaille Method (1974) we will look at the five following steps : Beginning state- Intrigue- Development – Resolution- Final state. According to this method, the plot is defined as a transformation from a balanced state (Beginning state) to another balanced state (Final state). The goal of the analysis is identified as how the biological phenomena connect to the different steps of the plot in the two stories.
On the other hand, we will examine the differents meanings taken on by problematic sentences throughout the story. How do the meanings evolve ? What new scientific questions will these new meanings provoke ?

RESULTS

Results 1 : The plot generate analytical and problem-solving tools

We will see how to fully understand the plot one must fully understand the scientific phenomena because the development of the plot in the two stories is overlapped with the biological phenomena (tableau 1).
The plot revolves around the relationship that unites two characters. In The tadpole's promise, the relationship is romantic, while in Fish is Fish, the relationship is between friends. In the two stories, the plot is based on the same disruptive event : the appearance of hindlegs on the tadpole which has the potential to threaten the relationship between the two characters. Is it possible for the relationship (love or friendship) between the two characters to continue despite the morphological and anatomical changes which effect the tadpole ?

The plot	***Fish is fish***	***Tadpole's promise***

<table>
<tr><td>Beginning state</td><td colspan="3">In two different environments, at the frontier between the pond and the bank of the pond (in Tadpole's promise: Where the willow meets the water a tadpole met a caterpillar.)
The opening places the development of the characters at the same time: when they are larva.</td></tr>
<tr><td rowspan="2">Intrigue development</td><td>First complication</td><td>Fact : The appearence of hindlegs on the tadpole distinguishes the tadpole from the fish, making them different.

Scientific problem: Is the appearence of hindlegs a clue that the tadpole does not belong to the same species of fish as the minnow ?
What can allow us to say that the tadpole is a fish or a frog?</td><td>Fact: The appearance of the two hindlegs on the tadpole changes the tadpole.

Scientific problem: Does the appearance of hindlegs change the identity of the tadpole?
Do these morphological changes exist for every animal?

→ The first complication happens three times: he grew legs, then he grew arms and finally he has no tail.</td></tr>
<tr><td>Second complication</td><td>When the tadpole develops into an adult frog and jumps out of the water onto the bank. The frog discovers the terrestrial world.

When the frog comes back, he describes to the fish the extraordinary things that he has seen: a bird, a cow and so on. The fish imagines the different animals.

Scientific problem: how can we imagine animals that we have never seen before? Animals</td><td>When the caterpillar develops into a butterfly but can't recognise the tadpole who has developed into a frog.

Scientific problem : does the same animal persist between the larva and the adult form?</td></tr>
</table>

		that don't live in our environment?	
Resolution		When the '*fish jumped clear out of the water onto the bank, … he lay gasping for air, unable to breathe or to move'. 'Luckily, .. the frog.. pushed him back into the pond'.* **Scientific problem**: Why can the frog breathe on the bank and not the fish, while the tadpole can breathe in the pond like the fish?	In *Tadpole's promise*, the resolution of the story happens when *the frog leapt up and swallowed her.* **Scientific problem** : Why can't the tadpole eat the caterpillar while the frog can eat the butterfly?
Final state		When the frog and the minnow remain friends. Each one stays in his environment. **Scientific problem** : what biological relationship exists between an animal and its environment?	The frog is alone, the butterfly has disappeared. *The frog waits thinking fondly of his beautiful rainbow wondering where she went.* **Scientific problem** : What becomes of the butterfly when she has been eaten by the frog? Is she still 'butterfly matter' or has she become 'frog mater'?

Tableau 1 : The events of the plot with the biological phenomena overlapped

Thus, in the two stories, biological phenomena are overlapped with the events of the plot. They are connected to each step of the plot and the plot is resolved according to real world restrictions.

Results 2 : certain wording generates problematic questions

Here the analysis consists of capturing the problematic dimensions of the storybook, which can often be found in either the title or the content of the story. In *Fish is Fish*, the problematic dimension is highlighted in the title. It is interesting to note that the French translation, *Un poisson est un poisson*, differs from the original English in the sense that the indefinite article, *un* , is used. This makes it clear that any fish, such as cod, trout, brill, bass, etc. can be part of the same specises. In *Tadpole's promise* the sentence *Promise you'll never change,* is repeated throughout the story and carries with it this problematic character. The promise is problematic because it is something that can never be realized. A tadpole will inevitably change into a frog.

Here we propose to focus on the different ways to read, question and understand the problematic wording : In *Fish is fish*, the changes in meaning occur while reading the storybook happens at two precise moments in the story.

1/ During the first complication

« One morning the tadpole discovered that during the night he has grown two little legs. "Look" he said triumphantly. "Look, I am a frog !" "Nonsense", said the minnow. "How could yo be a frog if only last night you were a little fish like me ! They argued and argued until finally the tadpole said, "Frogs are frogs and fish are fish and that's that !"

We can consider that the incomprehension between the two characters comes from different meanings seen in *Fish is Fish*. The two characters express implicitly ou explicitly two opposite meanings
For the fish: *Fish is fish* means implicitly that a fish stays a fish. The fish is considered as a single fish. Consequently the tadpole who is his inseparable friend and thus lookes like a fish will stay a fish. In fact, both characters are wearing the same green and red colors. Their expressions are similar, the graphics of the eye and mouth opening, give them a little « air de famille ».
For the tadpole : Fish is fish means explictly that a single fish is one member of the fish species.
If the fish gives the same meaning to the two fish terms, the tadpole gives a different meaning to each fish term, an expression that he applies to frogs and that he could apply to every specises.

The conflict of meaning permet de relier la question de l'identité à celle du développement. Plus encoe, The link between 'tadpole' and 'frog' (qu'exprime en parlant de grenouille et non plus de têtard) introduces the idea of the permanence of the identity of the animal during its development

Fish is fish, here is set against the truth spoken by the tadpole, who comprehends Fish is fish only from the point of view of frogs as a group
The use of the plural of 'grenouile' / 'frog' highlights the fact that the French 'un' (absence of pronoun in english) of the title refers to a plural.
The link between 'tadpole' and 'frog' introduces the idea of the permanence of the identity of the animal during its development

2/ During the resolution

The crucial experience of the fish allows the fish to test his beliefs about his identity. He could not breath on land like the frog, therefore he is not a frog but a fish. In this situation, the breathing becomes as a relevant criteria to define identity. The appearance of the hindlegs did not act as a criteria of distinction for the fish.
This time the fish gives explicitly with "you know, you were right, fish is fish" the same meaning as the frog does. We go from the truth about a single character (tadpole/frog) to a state of shared knowledge after an experience which almost cost the fish his life. *Fish is fish* is no longer only the truth about one character, but words proven by experience
This work opens up a reflection of the criteria of animal classification

CONCLUSION AND IMPLICATIONS

We propose to consider a new kind of picture book define as « realistic fiction », meaning that the narrative may convey certain elements of scientific knowledge
More precisely, these specific fictional storybook can be characterized as «realistic fiction» if :
- the story presents a fictional problem, which corresponds to a scientific problem,
- the fictional narrative is held together by scientific phenomena. The plots question the real world.
- there is a problematic wording

Thus, to fully understand the «realistic fiction», pupils must fully understand the scientific phenomena. In this way, such story book question beliefs ans interrogate our representations of the world allows one to explore the possible explanation by confronting fictional imagined worlds with the real world, allows one to connect the bordaries of the real world through the use of the imagined possible worlds which are created by fiction.
As Butzow (1998) said, in these books, we think that the scientific content is not merely a chance to introduce a reading, it becomes a « character » in the story, without which the book would cease to exist. The «realistic fiction» is not considered a pretext for introducing scientific content. Rather, it creates the context for the scientific problem. The both characteristics: multimodal aspects of texts and the association to the strong science theme related to the plot, open new perspectives for literacy learning. Such picture books represent an under- explored resource for teaching science at the primary school level. Our research perspective is to explore how these storybooks can be effectively used in the science classroom.

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TEACHING ANIMAL CATEGORIZATION IN PRESCHOOLERS USING TYPICAL - NON TYPICAL EDUCATIONAL ENVIROMENTS *

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Abstract: The aim of this research study is to present the goals, the content and some evaluation elements of a teaching intervention for preschool children concerning animal categorization. The intervention combines typical and non typical educational characteristics and takes place both in the school class and in a zoological museum. More specifically, we will present the cognitive objectives of the intervention which are the following: (a) the familiarization of children with various samples of animals, (b) the movement of children's ideas from using anthropomorphic or functional criteria to the use of morphological criteria for classification of animal samples, (c) the identification of new samples of animals with one of the constructed categories of animals and (d) the creation of a new class of animals in case of the animal sample does not fit in any of the constructed categories. In this study we will focus on the characteristics of teaching activities which take place during the visit to the zoological museum at the University of Patras. Some preliminary results which support the hypothesis that the museum educational activities have a positive impact on the fulfillment of the mentioned didactical objectives will be presented.

Keywords: Preschool education, zoological museum, animal classification, cognitive precursor models

INTRODUCTION

The present study is part of a wider research related to the design and evaluation of a teaching intervention which addresses to preschool children with the cooperation of school and zoological museum. The educational program is one of the forms of active involvement in school activities on science and technology (Koliopoulos, 2009), which promotes a structured scientific knowledge (Martin, 2004; Piqueras et al. 2008) and is regarded as a rich educational activity, which contributes to the achievements of scientific literacy (NRC, 1996). The latter form is usually based to the cooperation of the museum with the school, which, as noted, can combine the advantages of the museum and the school environment in order to achieve its full educational goals for visitors - students (Anderson et al., 2010). Studies have shown that students who have worked on subject before visiting a museum foundation and are prepared for the visit learn more from their experience (Griffin, 1994).

The objective of the teaching intervention is to be constructed by children a precursor model of classification of animals. Children learn about animals in a variety of ways. In zoos and museums, which children have been visiting ever since these establishments opened their doors to the public (Tunnicliffe & Reiss, 2000). The zoological museum of first generation is the oldest and most conventional type of museum where there are exposed collections of animals usually embalmed. This type of museum seems to be a suitable environment because of an explicit or an implicit way, it gives meaning to its collections through the concept of systematic classification of animals.

In parallel is has also been noted that children of this age can build precursor models of natural sciences through a socio-cognitive teaching approach according to which they are able to form explanatory forms compatible with both the knowledge of science and their own mechanisms for recruiting and processing knowledge (Ravanis, 1996). In this study will be present the goals, the content and some evaluation elements of a teaching intervention for preschool children concerning animal categorization.

THE DESIGN OF TEACHING INTERVATION

The principles of the design of the proposed teaching intervention are referring to (a) the structure and content of school knowledge on the subject, (b) the constructive approach of teaching and learning of science in early childhood education and (c) the museological conception on the teaching effectiveness of programs when they are carried out with the cooperation of school and museum environment.

The cognitive field which is the subject of teaching and learning in our case is the field, of the classification of animals. There are different theoretical starting points within which the concept of classification takes a different meaning. The currently accepted theory of evolution has led to the grouping of animals according to their relationships or the affinity of species (phylogenetic approach) and their common origin (genealogical approach). According to this theory the animal species are transformed and evolving entities and the hierarchical clustering result from a careful examination of similarities and differences in order to distinguish between the features which are due to their common origin and not the analog characteristics which are due to similarity in their function (Mayr, 1982; Lecointre, 2007). Is it possible through that, this epistemologically valid knowledge can be the scientific knowledge of reference for the teaching of the subject in preschool education? Our interest focuses of course on micro-classification, a field that is examining the methods and principles with which are identified and described the types of organisms (Mayr, 1982).

It is considered that in our approach it is impossible to introduce the types of living beings (here animals) as a biological species (taxa) in the modern sense of the term. In contrast, we use the concept of typological kind, which it may derive from theoretical framework where the notion of classification is recognized and becomes accepted without resorting to the theory of evolution, but it does not contrast with the concept of biological species). The typological (or morphological) type is considered to be a separate and stable entity, where the species are determined by fixed, key characteristics, usually morphologically. Scientists officially recognized a kind by defining a sample type that was recorded and deposited to a museum in order to represent the ideal form or morphology of the species' (Hickman, Roberts & Larson, 2001). Even today there are scientists who study only preserved specimens-types for which the dominant conception of species remain typological (Mayr, 1982; Hickman, Roberts & Larson, 2001). It is considered that this choice doesn't represent, at first an epistemological rupture between children's conceptions (who use mainly anthropomorphic or functional criteria to classify animals) and the knowledge where the criteria for classification of animals are purely morphological. It is also assumed, that the transition from the empirical criteria to criteria concerning the theory of evolution would be difficult or impossible because of the enormous distance between the two cognitive structures. So, the conceptual component of the proposed school knowledge is established, firstly as a didactic transformation of knowledge of the typological species and secondly, as a simplification of the collections of the Museum of Zoology of the University of Patras used as a museum reference. There are created, simple collections (Lecointre et al, 2007) and were formed four typological species, reptiles, birds, fish and mammals. As main morphological features of distinction between typological species were considered the anatomical characteristics and the nature of the skin (scales for reptiles, feathers for birds, scales for fish and hair for mammals). Yet they were established collections of samples of animals which form the phenomenological basis of intervention.

As for the methodological dimension of the proposed school knowledge, the emphasis was on the process of systematic observation of animals which responds to specific questions, is used to confirm some assumptions and is based on finding criteria of similarity or comparison (Guichard, 1998; Lecointre et al , 2007).

The constructive approach of teaching and learning of science in early childhood education is the second principle we take under consideration. This approach is based on assumptions according to which preschoolers can build conceptual models of precursor science (Zogza & Papamichael, 2001; Ravanis, 1996). It has been noted that the construction of these models can be possible within the interventions of teaching where the teaching objectives have been based on the cognitive obstacles or the general cognitive abilities of children of this age (Ravanis, 1996, 2005). Thus the teaching activities are designed so as to be used constructively the cognitive capabilities or/and removing the cognitive obstacles that children have (Ravanis, Koliopoulos & Boilevin, 2007; Koliopoulos & Argyropoulou, 2011). As for the construction of the concept of classification by preschool children, researchers note that children of this age use basically the anthropomorphic and the functional criteria (eg, habitat and movement) rather than morphological criteria to classify the different types of animals (Trowbrigde & Mintzes, 1988; Kattmann, 1998; Zogza & Papamichael, 2001). The proposed teaching intervention, therefore, emphasized on activities that aim at (a) the ability of the children to distinguish and name samples types of animals and (b) at shifting children's interest to the morphological characteristics of the sample-types through an organized and systematic observation of images and zoological exhibits. Examples of such activities are provided in the following section.

Finally, as for the educational environment in which will be implement the teaching intervention, was chosen to approximate three phases, each of which implemented in a formal (school) or non formal (museum) learning environment (Table 1).

Table 1 here

Each of the three instructional phases corresponds to qualitatively different educational activities (Allard, Boucher & Forest, 1994; Paquin, 1998). In the preparation phase before the visit, which takes place in school, questions are submitted and a discussion is developed concerning the museum object. On the phase during the visit which takes place in the museum, is carried out the data collection and analysis as well as the systematic observation of the museum object. Finally, in the phase after the visit which takes place in school, the aim is the further processing of data obtained in the previous phase, the drawing of conclusions and the evaluation of the constructed knowledge. This approach is based on an inquiry-based teaching and learning method engaging students in identifying relevant evidence and reflecting on its interpretations (http://fibonacci-project.eu/).

THE CONTENT OF TEACHING INTERVENTION

The cognitive objectives of teaching intervention which correspond to the desired cognitive progress of children are the following: (a) the familiarization of children with various samples of animals, (b) the movement of children’s ideas from using anthropomorphic or functional criteria to the use of morphological criteria for classification of animal samples, (c) the identification of new samples of animals with one of the constructed categories of animals and (d) the creation of a new class of animals in case of the animal sample does not fit in any of the constructed categories. Then we describe the key features of teaching activities which we assume that will contribute to the achievement of these objectives.

Activities prior to the visit

The activities carried out before the visit included activities where according to the principles of constructivist approach are investigated primarily the initial conceptions of children on the subject of teaching intervention. Within these activities the children are asked to recognize and name the samples of animals which are depicted in a series of cards which constitute the first simple collection of animals. In addition, children are asked to create groups of animals by classifying the various samples of animals which are depicted on the cards and indicate the criteria used. Finally, there are activities aimed at developing children's interest on their visit to a museum of Zoology.

Activities during the visit

These activities are carried out during the visit to the Museum of Zoology of the University of Patras. This particular museum exhibits mainly taxidermies animals placed in showcases that correspond to categories of animals, perfectly compatible with the typological categories of items that we seek to be constructed by children. There were introduced activities where children, through systematic observations, were asked to deconstruct the categories of animals that have been created in school and to compare their own categories with the categories adopted by the museum. Finally, children are asked to reconstitute the animal categories based on their observations and the emergence of common morphological features for each category. An example of an educational activity that took place in this phase is represented in Table 2.

Table 2 here

Activities after the visit

During the activities after the visit, experiences of the visit are invested in the construction of new knowledge from the children and the achievement of learning objectives of the program is assessed. More specifically, children were asked to compare the groups of animals which themselves had built at the beginning of teaching intervention to those created in the museum. They were also asked to include new images of samples of animals to the categories of reptiles, birds and fish, that were already familiar to them, or to suggest a new category (mammals) in case of the appearance of a new morphological feature.

THE COGNITIVE PROGRESS OF CHILDREN

The results of the analysis of perceptions of children's categorizations of animals came mainly from the *Pre – Post test (interview*), which took place before the beginning and after the completion of the educational program. We use individual semi structured interviews for all the children who participated in this pilot study- educational program. Complementary, the second unit of the results consists of the data which collected through observation of the subjects of the research, during the visit to the zoological museum.

The main conclusions which drawn after the final interview are as follows: Three of the nine children considered to have built a vision classification of animals based on purely morphological criteria, because they were able to identify, name and classify all samples of animals were given, while to suggest a new class of animals other than those which studied the museum and to justify their presence by using morphological data. Five of the nine children are in the process of building a culture of classification of animals based on morphological criteria .These children fail to nominate at least two categories of animals, but not always using purely morphological criteria (introduced, for example, the criterion of residence). They also recognize a new category of animals without name it. Finally, only one out of nine children who participate in this pilot study seems not to cognitive progress notes remaining on his original ideas.

Some complementary data which obtained during the children's visit the at the museum are indications that the activities of target observation suggested to the children contributed to the final construction of the classification of animals by using morphological criteria. Here are some examples of children's conversations with the researchers during the activity identification of exhibits on display in the zoological museum: "... This is a big peacock ... I have not seen it before" (Spiros). "... Look like a fish ... we see those in the sea during the summer , but here these look bigger " (Androniki). "... all snakes are here ..." (Themis). Infants also through the educational activity which took place during the visit to the museum identified the representative characteristics of each group (birds, reptiles and fish). "Here is the group of birds all have wings ... are all around, in the nearby showcases .... and small and large“ (Francesca).

The next educational activity which took place during the visit to the museum, where the children have to compare samples of animals depicted in these photos of exhibits and trying to assign each exhibit with the photograph, appears to be a suitable environment to move children from the original 'experiential' criteria for the classification of animals on criteria which mobilize mental representations based on the morphology of animals.
Characteristic is the phrase that Ianthi looking at an exhibit in a showcase says: "... This little bird is the same as what we saw in the photo at school ...and in this one ... has many ... colors in the wings ... and small legs as the other.:"[meaning the exhibit depicting in the photograph], (Ianthi). While Phoebus indicate "... but since that is not the same [pointing to the pairing just made his classmate between photography and the exhibit], a different color in the wings ... we decided to find the same ... this is the same“, (Fivos).

CONCLUSIONS

A key finding of the research activity developed during the planning of this educational program described here is that the collections of the Zoology Museum of the Univesity of Patras can be attributed by meaning, which can be potentially appropriate educational materials that will contribute to the cognitive and emotional progress of children of preschool education. Theses meanings come from both the nature and characteristics of the museum and, mainly, the objectives and content of each educational program. This means that the museums are possible through the model of educational program to upgrade the communications and educational role while simultaneously achieving objectives of the formal education.
The results of the program, in particular the activities undertaken during the visit, using the empirical basis of the museum (the zoology museum's exhibits) may provide an appropriate environment for children of preschool education to create a variety of meanings, to certain networks operating, rules and standards of interpretation, according to which they will 'translated' their experiences and assimilate the information from these intakes (Ravanis, 2005). So, if some of these networks of meanings, as in the case of the proposed program appears to be set up exactly due to the systematic interconnection of the contents of formal (school activities) and informal (museum activities) form of education, then demonstrate the functional re-

lationship between the two forms of education and this is a central hypothesis in our ongoing investigation.
The positive response of the overwhelming majority of children who participated in this program was another finding of this investigation. But this is not an unusual finding itself as the natural history museum with collections of "teaching remains an advantage that will make [visitors] to admire, be surprised and wonder (Van Praet, 1989). The important questions whether this response is and how the cognitive function in a privileged way is introduced in the proposed model of integrated curriculum. This is another interesting idea to be transformed as a research case study and in the future to be further explored.
*

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Before the visit	School	Preparation	Submit Question	Reflections on the museum object
During the visit	Museum	Completion	Data collection and analysis	Observation of museum objects
After the visit	School	Extension	Analysis and synthesis	Building knowledge through museum objects

Table 1: A three phases' model for the educational use of museum

Educational Activity	Cognitive Objectives
- The teacher - researcher asks the children to deconstruct the groups of samples of which were created at school and they are invited to put the cards which depict animal samples in the respective proposed showcases of the museum. - Subsequently the children are asked to construct groups of animals, placing the pictures with samples of animals placed in the same and / or in adjacent showcases in the same group. - Finally, children are invited to make assumptions for the reasons in which specific samples of animals belong in different groups of animals which were formed, turning the debate on the existence of morphological similarity criteria.	Children have - To identify and name images of samples of animals through systematic observation. - To modify the criteria of grouping of animal samples by using morphological criteria.

Table 2: Educational activity during the visit to the museum of Zoology

LEARNING SCIENCE IN SMALL GROUPS: THE ROLE OF AGE AND INTERACTIONS

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Abstract: In the present work we study young children's learning in science in mixed-age small groups. Specifically, we study the performance in science of the younger students participating in these groups, as well as the development of their communication-collaboration skill in an effort to diagnose if these factors are influenced by the number of the older students participating in the groups of a class. Four schools with classes of students aged 4-6 participated in the study. Students were involved in activities with topics from physics and astronomy. Two sources of data were used: Teachers' classroom recordings and children's individual assessments. Results indicate that there is a linear relationship between the performance of the younger children and the number of the older ones that participated in the groups of each of the classes. Similar results were recorded for the communication- collaboration skill. The graphical representation of the younger children's performance in science versus the number of the older children participating in the small groups allows us to predict the expected performance of the younger children of a class depending on the age composition of the groups. The latter can be utilized in deciding the age composition of the small groups in a class with the aim to facilitate the younger children's learning as well as their social interactions.

Keywords: Small-group-learning, Science learning, Preschool science, Mixed-age groups, Social interactions

BACKGROUND AND PURPOSE

Students' learning by interacting with each other than only with their teacher is of much interest to educational researchers and practitioners; it is also a highly evaluated goal (Webb, 1989). To achieve this goal students need a learning environment that promotes the interactive processes of learning which they are preferably exposed to from the lower grades of education (Huber & Huber, 2007). At the heart of this view of learning is the situation or the context within which learning takes place. Taking into consideration that learning is a transactive phenomenon existing in situations created by the teacher for students to learn, and that social interactions and skills allow the individuals to benefit from the opportunities to learn from each other, the teacher can create environments in which students can collaborate with peers and adults. Examples of such are the small mixed-ability cooperative groups the use of which is supported by extensive evidence produced by numerous studies. Small cooperative groups are used in several countries across all levels of education not only for supporting and improving students' learning, motivation and attitudes, but also as a method for handling classes with a large number of students. While small-group-learning has a long history, only in the last decades have researchers studied the interactions among students that facilitate learning, and the factors that lead to different patterns of interactions. One of the factors is the number of the members who participate in a small group. Huber and Huber (2007) suggest that groups should comprise as many members as are still able to interact directly with each other. Another factor that has proved to be important is the age of the members of a small group. Furman and colleagues (1979) maintain that socialization in mixed-age groups serves children in many ways that same-age socialization does not and note that in mixed-age groups, accommodations are required between individuals whose developmental level differs. The following findings are also of importance: a) Children prefer to be taught by children older than themselves (Allan and Feldman, 1976), b) Older children are more effective models than younger children (Peifer, 1971) and c) Reciprocal imitation is more characteristic of children's interactions with older children than with younger children (Thelen & Kirkland, 1976).

Given the above, in the present work we study learning in small mixed-age groups. More specifically, we study the performance in science of the younger children participating in these groups, as well as the development of their communication-collaboration skill in an effort to diagnose if these factors are influenced by the number of the older children participating in the groups. The questions leading our research are:

- How do the cognitive achievements in science of the younger children of a class the students of which work in small groups change in relation to the number of the older children participating in the groups of this class?
- How does the communication-collaboration skill of these children develop over the period of their involvement in science activities?

DESIGN AND CONTEXT OF THE STUDY

The present study, which was conducted in Greece, was designed to be carried out in real classroom settings. Given that in the Greek educational system the only level in which classes are mostly multiage is the pre-primary, the present study was carried out in classes of children aged 4 to 6. In this level, ages are grouped as follows: 4-5 pre-kindergarteners (PKs) and 5-6 kindergarteners (Ks). Four schools participated in the study. Three of the classes were attended by children aged 4, 5 and 6 years and one by PKs only. In all classes children worked in groups. Traditionally, group work gathers 4 to 6 students (Huber & Huber, 2007). In our study, groups of 5 students were formed. We considered that this is a number that provides good opportunities for interactions between members and for making different combinations of ages in a group. Considering that each individual child has a probability of interacting with each of the rest of the members of the group, we assumed that when the number of PKs is smaller than that of the Ks, each of them will have a higher probability of interacting with an older child. Thus, for the purpose of our study, we differentiated the number of Ks participating in the groups of each of the classes keeping the total number of members at 5 (all groups of a class had the same age composition).

In all the classes the teachers implemented science activities with topics from physics related to the states and properties of matter, the magnets, heat and temperature and motion and topics from astronomy related to the shpericity of the earth and the phenomenon of day and night (see Kallery, 2009 and 2011). Activities were hierarchically sequenced in order to support construction of meaning. Implementation started in October and ended in May. All teachers participating had a long experience in teaching science at the pre-primary level.

DATA COLLECTION AND ANALYSIS

Data was derived from two sources: a) Teachers' recordings made during all the stages of the activities' implementation and b) The post-instructional assessment of the students. In order to evaluate how each team member has benefited personally, children's assessment was individual. Assessments started in January, after the children had completed the first cycle of activities, and were carried out monthly until May. Teachers' recordings included: a) separate evaluation of PKs and Ks cognitive achievements in class, for each month from October through May, and b) the development of the communication-collaboration skill for each month.

The analysis of the students' answers to the post-instructional assessment classified them in two categories: 'acceptable' and 'non acceptable'. Acceptable answers were assigned the value 1 and the non acceptable the value 0. The percentage of the PKs' success for a specific evaluation task was then calculated. From these findings, the average percentage of the performance of these children was estimated. The analysis of teachers' classroom recordings was done in group sessions of the teachers and the researcher (author of the present paper). In this analysis, the teachers, based on their recorded information and the experience they gained from their interactions with the children, quantified the children's cognitive achievement assigning percentages for each month. The final value for the children's performance was found by calculating the average of the children's performance in the classroom and the performance in the individual assessments for each month from January to May. On the same basis, teachers quantified their recordings for the development of the communication-collaboration skill in the children providing for each month a percentage.

RESULTS

Results for both factors investigated were plotted for the younger children of each of the classes. Two representative graphs are these of Figures 1 and 2 where E_p is the PKs' performance. In these Figures graph B represents classroom data, C the individual assessments and D the average of B and C. The maximum value which the children's performance reached, as well as the point at which it stabilized is shown.

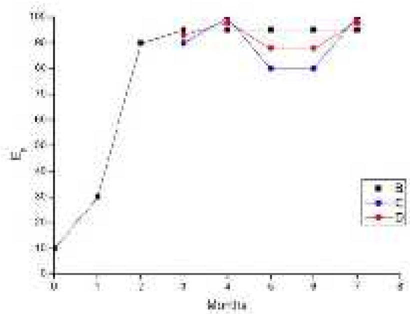

Figure 1. Performance of the PKs of a class with group composition 1PK and 4 Ks.

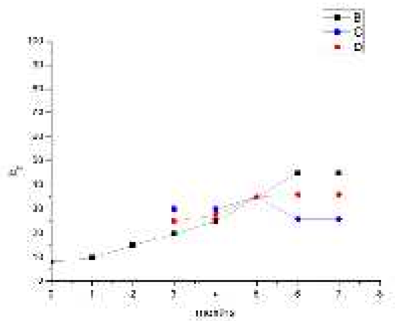

Figure 2. Performance of the PKs in the class attended by PKs only

These graphs also provide information on the length of the time in which the younger children of each class reached the maximum of their performance starting from the time they begun to collaborate with the older children in science activities. These findings were plotted and gave the graph of Figure 3. Evidently, the larger the number of older children in a group, the faster the younger ones reached the maximum of their performance.

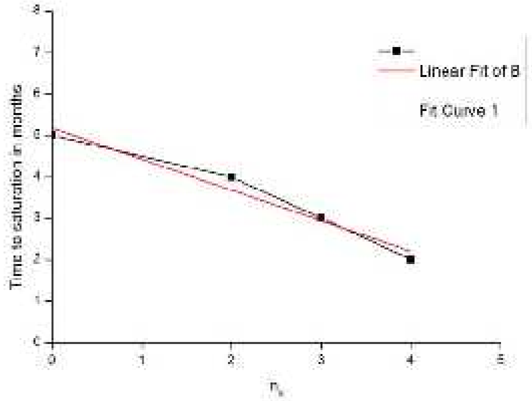

Figure 3. Time in which the younger children of each class reached the maximum of their performance in relation to the number of the older children participating in the groups of each of the classes

Similarly, graphs were plotted for the communication-collaboration skill. Two of these graphs are presented in Figures 4 and 5.

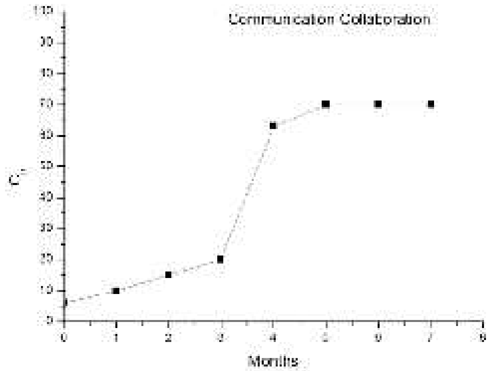

Figure 4. Evolution of the factor communication-collaboration in a class with group composition 3PKs and 2Ks

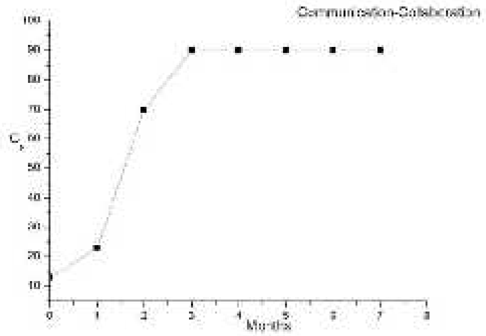

Figure 5. Evolution of the factor communication-collaboration in a class with group composition 2PKs and 3Ks

Using graph D the average performance for the months January to May for the PKs of each of the classes, as well as the uncertainty ranges of the average, were calculated. Plotting of these values gave the graph of Figure 6 which represents the performance E_p of the younger children in relation to the number of the older children n_k that participated in the groups of each of the classes

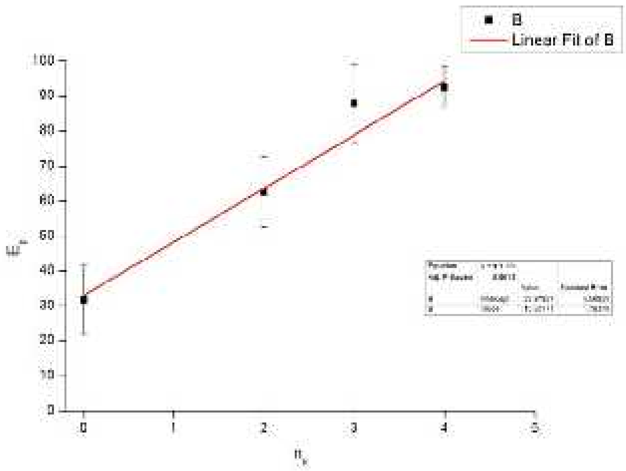

Figure 6. Performance of the PKs of each class in relation to the number of the Ks participating in the groups of each class

The graph of Figure 6 indicates that there is a linear relationship between the maximum of the performance of the younger children and the number of the older children participating in the groups of each of the classes. Based on this relationship the expected performance of the younger children of a class can be predicted depending on the age composition of the small groups of this class. These results were verified in two other groups of 6 members (formed in

two of the classes whose the number of students was not a multiple of 5 which had different age compositions (4Ks and 2Pks and 2 Ks and 4Pks) with very small variations (4% and 1% respectively).
Similar to graph of Figure 6 was the graph representing the communication-collaboration skill of the younger children.

CONCLUSIONS AND IMPLICATIONS

From the present study it can be concluded that in mixed-age small-group-learning in science, the age composition of the groups can significantly affect 'cognitive achievement' and 'communication-collaboration', and preferentially determine the time in which these factors reach their maximum value. The results can be interpreted on the basis of the findings of other studies reported in the introduction (Allan and Feldman, 1976; Peifer, 1971; Thelen & Kirkland, 1976) which have shown that younger children learn from the older ones, who constitute effective models for them. The present study not only provides qualitative verification of these interpretations, but also quantifies the role of the age composition of the small science learning groups of a class. Based on the above, the selective composition of groups with a larger number of older children who have more advanced communication and cognitive skills in science can be used to facilitate younger children's learning, as well as their social interactions (see Furman, Rahe & Hartup, 1979).

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A DIDACTIC PATH FOR AGE 5-8 ON THE CONCEPT OF EXTENSIVE QUANTITY USING A STORY AS COGNITIVE TOOL

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Abstract. We present a didactical path for the introduction of the concept of extensive quantity using a story as medium. We assume that stories can be suitable for pupils aged 5-8 as emotional, cognitive and imaginative tools. Teachers can make use of stories as a methodological scaffold, useful to design and lead the activities. The story, together with the experimental activity, can foster children's verbal production. Moreover we want to give teachers the ability to move from the level of the experimental activity and the pupil's verbal description of their actions to the level of scientific meaning of the same words/actions. This can be achieved providing teachers with a series of examples of words and phrases that pupils may use, and have to be recognized as indicative of the relevant concept.

Keywords: Early science education, extensive quantities, story, semiotic mediation, substance-like quantity

INTRODUCTION

Teachers' elementary ideas on physics have been investigated (Kruger et al., 1992; Greenwood 1996; Atwood et al. 2001), showing that they often share the same alternative conceptions of their pupils. This fact is often considered as negative. However, the results of cognitive sciences and cognitive linguistics in articular (Johnson, 1987), show that at the basis of human thinking, and so also of scientific reasoning, are some elementary and fundamental concepts shared by the everyday experience. These concepts, called image schemata by some authors, are pervasive and emerge in language, at any level of formalization, from common language to scientific language. This means that, at least at primary school level, science education can rely on these elementary concepts, to develop them in order to base the scientific concepts that will be utilized for higher grades of instruction. In early science education the image schema of substance is fundamental, because by one hand it is the most basic gestalt that children (and adults) use spontaneously to represent and describe the reality seen through everyday experience, and on the other hand it represents a fundamental element for the formal scientific knowledge (Fuchs, 2007). The substance image schema corresponds to the scientific concept of extensive quantity.

An image schema is used to make meaning by metaphorical projection onto phenomena (Lakoff & Johnson, 1980). The figurative-metaphorical thinking characterized by fantasy, rhythm and narration, images, storytelling and emotionality (Egan, 1986) is the main source for the formation of hypotheses, which are required for interpretation and modeling of experimental activities. Literature suggests the use of stories and storytelling to promote emotional (Egan, 1989; Campbell, 1996) cognitive (Egan, 1989; Ellis, 2000) and imaginative (Egan, 1989; White, 1981; Klassen, 2007) involvement of pupils.

Bringing stories into science teaching derives from the evidence that an effective learning is achieved if children are both cognitively and emotively involved (Bruner, 1994). Pupils, under the guidance of the teacher which should suggest inquiry questions and help them to evolve their thought, take so an active role in building knowledge through formulation of hypotheses or explanations, identification of problem variables, hypotheses testing (Mariani et al., 2010).

In our approach the story represents also the way to help teachers from a methodological point of view. It represents a sort of scaffolding of intellectual steps and practical activities to focus on the elementary recurring concepts that are the goals of the didactic path. The story, according to this approach, acts as a background element, which fosters the ability both on the creative-imaginative and on the logical-deductive sides.

In this paper we draw a proposal for a didactic path, inspired by semiotic mediation framework for the mathematics laboratory activity (Bartolini & Mariotti, 2008), on the concept of extensive quantity, in which meanings are constructed through teacher guided stories, experiments and class discussions.

AIMS

The main goal of this didactic path is to introduce pupils of age 5-8 to the achievement of a good mastery of the concept of extensive quantity. In our aims, this path represents a methodological framework in which children and teacher can work together.

A STORY ON SUBSTANCE-LIKE QUANTITY: "RUPERT AND HIS FRIENDS AT THE LUNA PARK"

In this path we focus on the three aspects (properties) of the substance-like quantities:

1) Production/destruction
2) Transfer (distribution and accumulation)
3) Conservation

The "Rupert and his friends at the Luna Park", composed of various episodes to be used in different lessons, is the first of a series of stories that accompany the children through the years of primary school. On the methodological side, teachers are invited to design the activities following the path of the story, but they are free to modify and plan the activities according to their own specifications and needs. The teacher relies upon the story to set the correct sequence of steps, starting from simple to the more complex concepts. In the story, as substance-like quantity we choose the ice cream, which can be used, with different levels of interpretation, to show all the three properties. Moreover, it can be considered both a mass and a countable (ice cream balls) substance. We propose the use of a story containing few episodes showing different situations in which a group of friends are at the amusement park and they deal with ice cream balls. Some properties of the substance-like quantity are investigated at different levels, during the different episodes of the story.

At the beginning, the main characters that lead the pupils through the episodes are presented. Children can identify themselves with these characters and are involved in the solution of the problems that the characters meet, trying to ensure their help. The main characters who are the protagonists of all the episodes are: Pico, who represents "The Little Scientist", curious, attentive, ready to be amazed by the facts occurring around him, but also generous and always ready to help his friends when they meet some problems which they are not able to solve; Rupert, a frog, enthusiastic and curious, but always too quick to draw conclusions, often with awful results; Merlo, a blackbird, who, as a bird, can see the things happening from above, a sort of advisor for Pico and Rupert. The three main characters constitute a kind of emotional identification for the children's, but there are also some features that can be set on a more "cognitive" (or at least methodological) level: Pico, for instance, always brings with him a sketch book, on which he writes the accurate description of what happens, and suggests that pupils can do the same. He represents the "scientific method" and is able to formulate the "good" questions, so children are stimulated to do the same. Moreover, every episode of the story ends with a question posed by Pico, who asks for the help of the pupils to solve a problematic situation. Children in the class are both audience and actors of the story being told: in the beginning they watch the development of the story, but soon they are required to help the characters (Corni et al., 2010).

In the first episode the characters buy some ice cream and they wonder how much ice cream they have all together; after that, they start to exchange ice cream balls to try different flavours, and they notice that the substance can be compared and measured; in the end some ice cream exits the boundary of the amusement park.

In the second episode the story focuses again on the ways of making a comparison between different quantities of ice cream; moreover introduces the addition and the subtraction of ice cream balls, and the fact that when some ice cream balls fall on the ground they are not "eatable" anymore, so the total ice cream amount is reduced.

In the third episode the story introduces the proprieties of the countable quantities: the "transitive property" of the comparison.

In the fourth episode the story focuses on the difference between quantitative and qualitative (colour, flavour) aspects of a substance and try to differentiate them.

In the fifth and sixth episode the story presents different ways to verify the properties of substance-like quantities in the case of non countable substances, such as lemonade, or in the case in which counting is not sufficient to determine the amount (ice cream balls of different sizes).

HELPING TEACHERS TO INTERPRET PUPILS' PHRASES

An important goal is to help the teacher to move from the pupils' verbal level, to the recognition of the underlying scientific meaning. This can be achieved providing the teachers with a series of examples with some possible situations and helping them to recognize, according to the semiotic mediation framework (Bartolini & Mariotti, 2008), some "pivot words" that pupils may use, indicative of the relevant concept. For every situation, some examples of "pivot words" and possible situated text (sentences that teachers can expect that children will say/write) are given, with the related scientific meaning.

The following table is and extract of the compete table that suggests how the different properties of substance-like quantities can be recognized in the words of the children. The *situated text* shows examples of how the children can talk or write about the situation. The "*pivot words*" are the word that the teacher can use to recognize the reference to the specific property. The *scientific text* is the description, or definition, that the teacher can bear in mind and use as a reference (and doesn't have to be explicated to the children).

During the class discussion the teacher, starting from the situated text i.e. the pupils' phrases expressed in natural language, uses their "pivot words" to construct scientific meaning.

Property	**Situation/question**	**Pivot words**	**Situated text**	**Scientific text**
Production	The friends buy the ice cream from the ice cream man	The ice cream is made, the ice cream man prepares the ice cream	The ice cream man produces the ice cream from its ingredients and a recipe.	A substance-like quantity can be produced
Comparison	How can we tell who has more ice cream?	Number of balls, number of ice creams, comparison, to weight, to count	Counting the balls of ice cream we can say who has more. We compare the ice creams by means of their weights	Substance-like quantity can be measured and compared.
Transfer and	If someone gives one ice cream ball to	Number of balls, one more, one	If I give one ball to you, I will have one less and you will	A substance-like quantity can be

conservation	somebody else, how is the total amount of ice cream?	less, comparison, the same, altogether, transferring, giving/receiving, adding/subtracting	have one more. The ice cream amount that I give you is the same that you receive. The total amount of ice cream remains unchanged.	transferred preserving its total amount.
Transfer and conservation	If somebody leaves the park do we still have the same total amount of ice cream?	Number of balls, amount of quantity, transferring, total amount, park boundaries, inside, outside, before, after	The total amount of substance is the same, if we take into account the quantity both in and out of the park.	The amount of a substance-like quantity in a particular system increases or decreases according to the amount passing through the boundary.
Destruction	What happens to the ice cream when it is eaten or it drops on the ground?	Ice cream disappears, it melts, it is digested	The ice cream can change and become melt or decomposed.	A substance can be destroyed

CONCLUSIONS

We have outlined a didactical path for pupils aged 5-8 to introduce the concept of extensive quantity using a story as medium. We assume that stories can be suitable as emotional, cognitive and imaginative tools. Teachers can make use of stories as a methodological scaffold, useful to design and lead the class activities. The teacher has to be trained to recognise "pivot words" in the classroom discussion to become able to guide pupils from the situated level of description to the scientific level of giving meaning to things. Possible experimental further research could investigate the ability required by the teacher to use such a framework. Moreover, it could be useful to design analysis grid to interpret pupils' verbal and written productions to assess effective learning.

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IDENTIFYING AND ELABORATING EMERGENT SCIENCE WITHIN A HOLISTIC APPROACH TO THE FOUNDATION PHASE CURRICULUM

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Abstract: The paper describes the research-based design of a 'Child Development Assessment Profile' (CDAP) for use by practitioners in the Foundation Phase in Wales. The need was for: i) a holistic perspective on development; ii) high quality, comprehensive support materials that defined clearly the behavioural criteria selected as the focus for attention (acknowledging their value in continuing professional development) iii) the manageability of all procedures and iv) the added value that the introduction of the CDAP would contribute to practice in planning and professional development. The broad age range addressed by the CDAP invited its use for the original benchmarking remit, but also for assessment for learning. The use of the CDAP as a tool for practitioners' planning was made possible by the close integration of the behavioural criteria with continuous provision in settings, the emphasis on developmental progression, and the mapping of developmental trajectories to end of phase designated Outcomes. Some features of the CDAP relevant to emergent science are discussed. Given the holistic intent, aspects of the six domains by which the CDAP is structured are enabling of other capabilities. Others have a much clearer bearing on aspects of scientific thinking. The authors describe the potential for the CDAP as a tracking device for practitioners and as a developmental research tool for science educators seeking to identify and nurture behaviours relevant to emergent science.

Keywords: emergent science, early years, assessment, progression

BACKGROUND, FRAMEWORK AND PURPOSE

'Emergent science' is recognised increasingly as an area for serious consideration within early years education. In England, the commitments enshrined in the Early Years Foundation Stage (2008) include encouraging children's play and exploration to promote active and autonomous learning through which children choose and find out for themselves new ways to do things (Tickell, 2011). Similarly, the Welsh Government has prioritised the fostering and support, through innovations in its education system, of independent, metacognitive and autonomous learners with an emphasis on skills development. An innovative 'Foundation Phase' framework is currently being implemented across Wales with a distinct shift away from formally structured and timetabled curricular demands towards a more child-centred provision. It is in this context that the authors were contracted to develop a Child Development Assessment Profile (CDAP).

The CDAP is to be used statutorily to assess children's capabilities on entry to the Foundation Phase. Entry must happen some time between the ages of 36 and 60 months. The instrument will, in addition to benchmarking on entry, have formative and diagnostic use in tracking children's development.

The development process adopted a collaborative, research-based design, inclusive of practitioners and subject to iterative formative evaluation. Expert validation was emphasised. Assessments had to make good sense to practitioners in terms of the behaviours they were attempting to promote amongst the young children in their care. The R&D procedures also paid careful heed to the issue of manageability. The intention was to ensure the ecological validity of the assessment activities. The behaviours practitioners were asked to assess and the manner in which they were invited to assess them should not seem misplaced or exotic in the context of the settings in which they took place, so were designed around the very kinds of behaviour that it would be appropriate for practitioners to foster as integral to the spirit and practice of the Foundation Phase.

This CDAP remit required an extensive review of the literature relevant to early childhood development, calling on the published expertise from a range of disciplines: developmental psychology, neuroscience, paediatrics, etc. The intention was to identify established developmental milestones associated with norm-referenced information as key markers in the developmental assessment of outcomes in early childhood education. It was possible to draw on previous research in this regard (Kagan *et. al*., 2004; Evangelou *et. al.,* 2009; Welsh Assembly Government, 2009). The tentative prototype frameworks designed on the basis of relevant literature had then to be tested by practitioners for validity, reliability and manageability. This was achieved through several several iterations in order to arrive at a state that satisfied both the commissioning agency and other stakeholders.

Given the authors' special interest in science education, these broad empirical lines of enquiry offered an opportunity to reflect on and seek clues to the antecedents of what might be thought of as a more specifically scientific way of thinking within the holistic and informal learning context that was the required starting point. We stress that these science-specific aspects were not part of the CDAP remit, but reflected our special interest.

RATIONALE

Within a holistic framework, we consider the characteristics of 'emergent science' that might be identified in the early years. The motivation for doing so is not to plead a special case for fostering scientific literacy or the production of future scientists. Nor do we seek to displace other curriculum special interests by favouring science, or suggest special programmes to identify prodigious talent, as happens in some subject areas (music, sports, the arts, etc.). Our intention is to identify science-relevant behaviours that might be the subject of nurturing attention through an analysis of appropriate pedagogical content knowledge (PCK). We seek to sharpen the focus of the kinds of intervention that might be possible to foster 'scientific thinking' across the variety of Foundation Phase settings. We speculate on learners' progression in the science-relevant capabilities identified and anticipate the means by which practitioners may facilitate their further development. The holistic context within which specialist science interventions can be promoted is accepted explicitly. The interrelated nature of the different areas of learning and development are understood and it is acknowledged that children's early education must be broad and expansive, based on as wide a set of experiences and expert support as can be made available.

METHODS

There are two distinct methodologies to be reported in this work.

The first methodology is the *empirical* grounding in the form of the development of a 'Child Development Assessment Profile' (CDAP). This happens to have taken place in Wales (and was therefore developed in bi-lingual Welsh and English forms). Although there will be divergent views in the priorities present in any country's early years curriculum, there is also a large degree of consensus, so much the same processes might have taken place anywhere internationally.

The second methodology is more conjectural, being the *theoretical* mapping between the generic capabilities to be supported and assessed in the early years and the typical constituents of science-specific curricular expectations. We try to avoid a parochial stance by referring to what we consider to be some general characteristics of science curricula for younger children. This theoretical mapping is an attempt to identify

the antecedents of science-specific behaviours

the manner in which progression in those behaviours might be described, and

the kinds of responses or interventions practitioners might plan to support and foster scientific thinking

Empirical Element

This two-year CDAP R&D programme commenced with a desk review of the Welsh Government Foundation Phase policy documents and guidance, supplemented by evidence from relevant international cognitive-developmental literature. Consultation and expert validation with representatives of all stakeholder groups was undertaken. Small-scale and large-scale trials (n= 128 settings, 503 children, Nov. 2009) and a national pilot (n=269 settings, 1195 children 24-94 months, April 2010) informed the development and refinement of assessment criteria and the structuring of the domains to be observed and assessed. Practitioners were invited to implement draft guidance materials and to assess their children's capabilities using the materials. Their assessments were analysed and their qualitative feedback coded and classified. The authors acknowledge that individual children's progress may not be smooth (Siegler, 2005). Nevertheless, it can be argued that developmental trajectories can be inferred from the empirical data, which focused on age-related progression of performance within criteria, the integrity and appropriateness of the domains for children's development and practical manageability. Outcomes led to a reformulation of the domains, refinement of criteria and elaboration of the supporting guidance materials.

RESULTS

The CDAP in its final form describes seven age-related steps, covering an age range of 30-84 months, within each of six domains, and totalling 114 assessment criteria. Detailed guidance materials include narrative descriptions of developmental progression in each sub-domain and detailed illustrations of the criterial behaviours. The range of providers includes child minders, playgroups and nurseries, some of these settings attached to schools and including practitioners who may have little or no relevant training or qualifications.

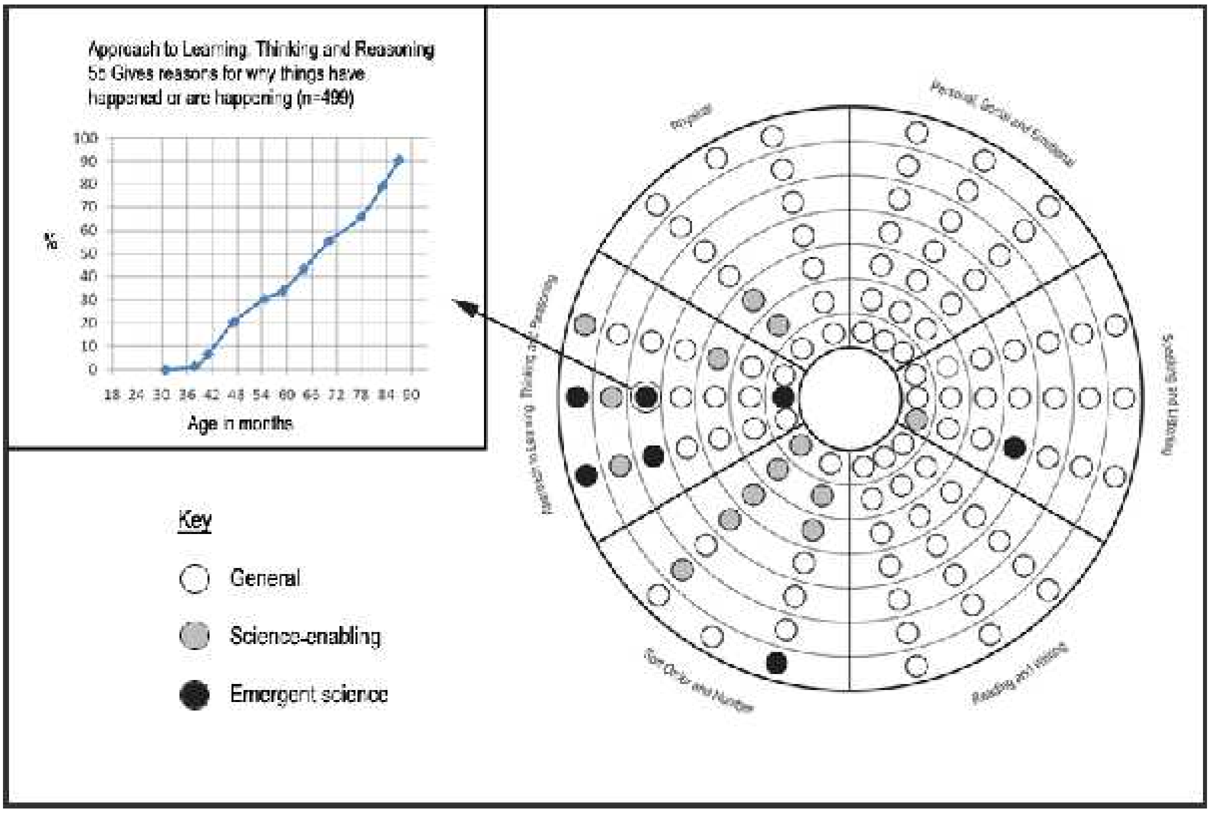
Figure 1 shows the design of 'Record Wheel' with its six domains of development: Physical; Personal, Social and Emotional; Sort, Order and Number; Approach to Learning, Thinking and Reasoning; Reading and Writing; Speaking and Listening. (Creative Development is treated as a cross-cutting theme.)

Each small circle represents an assessment criterion with progression in complexity radiating from the centre outwards in seven 'steps'. The inset graph shows the kind of cross-sectional-by-age performance data that was required to check developmental progression in any given attribute.

While a case might be made for the relevance of every domain and every criterion within it to emergent science, more stringent considerations have been applied. In Figure 1, emergent science criteria are shown as black circles, while science-enabling criteria are grey, with the remainder clear.

During the course of the CDAP development, researchers and practitioners identified illustrative examples of behaviours relevant to emergent science. In the space available it is only possible to illustrate how selected criteria in one of the domains, that of 'Approach to learning, thinking and reasoning', can be thought of as science specific. Each of the criteria used to assess children's developing capabilities within the domain are presented. The criteria selected as science specific are highlighted.

Figure 1. 'Record Wheel' for the Six Domains of Development



This developmental area identifies milestones in the development of the confident dispositions that enable the learner to take ownership of and actively influence their own learning and the learning of others. While many of the criteria in this area can be thought of as making a general contribution to children's development such as the capability to persist in the face of challenges, there are several criteria that can be argued to represent science relevant behaviours that might be the subject of nurturing.

1a Curious to know what is inside boxes and containers

1b Looks for or orients towards a dropped object*

1c Uses objects as intended

2a Maintains attention for about one or two minutes on a chosen activity

2b relates an experience today to one that happened in the past

2c Experiments with effect of own actions on objects and people

3a Shows curiosity about their wider environment and wider surroundings

3b Uses actions or words to indicate why one activity is favoured over another

3c Describes experiences or objects in speech, drawing, modelling, construction, movement or music

4a Remains engaged in an activity for at least 10-15 minutes at times

4b Remembers events in the past and uses these to anticipate events in the future

4c Takes on pretend roles and situations…

5a Chooses to work on a project because the activity is of personal interest

5b Gives reasons for why things have happened or are happening*

5c Can explain how things might change, given changes in circumstances*

6a Copes with reasonable challenges, shows persistence…

6b Can hold more than one point of view

6c Can describe a sequence of events in a logical way

7a Reflects on and evaluates the strengths and scope for improvement in their own work

7b Plans the steps in an enquiry and explains decisions about the approach*

7c Explains if a story is real or make believe, when prompted*

Criteria 5b and 5c are associated with the development of causal reasoning. The reasons children offer for events may not always be correct. They may be based on prior experiences, limited evidence or imagination. Nevertheless, in such instances children are showing a willingness to think about effects and their causes. These behaviours can be thought of as science relevant and can be harnessed and nurtured accordingly.

Similarly, children's capabilities to 'plan the steps in an enquiry' might be thought of as a milestone in the journey towards planning an approach to a scientific enquiry. Children's early planning skills might gradually evolve from the more general sequencing of steps to include some of the characteristics of managing a scientific investigation such as the identification and management of variables.

As might be expected, the identification of indications of science-specific criteria is not straightforward. The ways in which capabilities in various domains mutually interact and influence development has to be recognised. Some criteria that are important for science such as, 'Can hold more than one point of view', although associated with one domain in the generic CDAP call upon a complex set of behaviours when analysed from the science-specific perspective. For example, language development has an important role to play in the oral expression of ideas and the child's developing capabilities to ask questions, consider different viewpoints and seek evidence. Willingness to express ideas, to suggest ideas for enquiry and to engage in debates around the meaning of evidence requires not only language and communication skills but also a developing sense of self as an individual having ideas. In this context, the development of a 'theory of mind' (ToM) with a sense that others may have different ideas is a critical emergence. Children will need social and emotional competence so that they can participate effectively in discussions in which they make suggestions, offer explanations and perhaps give feedback on other children's ideas. Differences in the ways children explain their thinking or call upon evidence to explain how they know might be influenced in turn by their reasoning and number capabilities.

CONCLUSIONS AND IMPLICATIONS

This paper has described an approach to the establishment of an holistic assessment framework for children in the Foundation Phase and from this, has identified some science-specific indicators which might be present in early years provision. There are grounds to suggest that the CDAP provides a developmental framework that might be used by researchers and practitioners to explore systematically science-specific interventions in early years practice.

Research into the benefits of early years education (Sylva et al., 2008) suggests that its *quality* must be the overriding concern, not simply its presence or absence. This being the case, the identification of the antecedents for later scientific modes of thinking should equally compel a consideration of the quality of associated experiences and interventions. Kallery *et al.* (2009) sound a warning in suggesting that in their early years research, ‘the didactical activities analysed did not promote scientific understanding’. There remains work to be done in identifying emergent science and in enhancing the quality of didactics in the form of planned and targeted evidence-based interventions to facilitate its development. The provision of practical, open-ended experiences advocated in the early years curricula cannot be assumed to be ‘high quality’ or ‘enabling’ in terms of developing scientific thinking until we have clearly identified what behaviours are relevant, what they look like in the context of continuous or targeted provision and how practitioners might respond in ways that foster scientific ways of thinking in young children.

In addition to its use as an assessment for learning (AfL) tool, the defining of assessment domains and observable behavioural criteria argue for the CDAP instrument’s use as a developmental research tool for science educators.

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FROM FICTION STORYBOOK TO SCIENTIFIC MODELING: AN EXAMPLE IN PHYSICS TEACHING AT PRIMARY SCHOOL

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Abstract: This contribution is part of an interdisciplinary research about the use of storybooks in order to design and implement teaching sequences at primary school. We call these storybooks "realistic fiction" because they mix together fictional elements and scientific knowledge. Our thesis is that modeling the physical world of fiction is a relevant tool for modeling the physical world of our reality. This contribution shows that the storybook "*Plouf !*"[1] provokes an epistemological questioning among 7-8 years old pupils. The sequence operated semiotics substitutions in order to understand the notion of mass and construct a model bridging fiction and reality. The dialogues in the class show the ability of students to discuss the conditions of validity that the situations in question, fictional and real ones, should complete from the physical point of view.

Keywords: Realistic storybooks; Modeling; Physics; Primary school

INTRODUCTION AND AIM OF THE RESEARCH

We are engaged in an interdisciplinary collective research and we are studying the use of storybooks in science learning at primary school. We call "*realistic fiction"* a category of storybooks in which the fictional world and the real world overlap and are mixed together (such as *Fish is fish*, L. Léonni (1970); *Plouf,* Corentin (1991)) (Bruguière et al., 2007; 2009). In these books, the story follows the usual narrative fiction rules (personifying, intrigue, episodes), but it is not completely unreal, because it collides with the resistance of laws of nature (such as physical and biological phenomena). Consequently, these fictional storybooks implicitly contain some elements (questions, facts, knowledge) which agree or conflict with the scientific interpretation of the phenomena of the world. But there is no intention to popularize.
Our contribution is to show how the storybook "*Plouf"* (Splash) can be used by a primary school teacher to provoke epistemological questioning which leads pupils to construct a model of the underlying physical situation in this "*realistic fiction"* story.

ISSUES AND THEORETICAL FRAMEWORK

Fiction as contextualization in science learning

Several researchers consider fiction as a representation of a possible world, "whose function is to provoke, for a reader, the imagination of some content" (Barberousse et Ludwig, 2000). Following these authors, we argue that the fictional storybooks cannot be reduced to pure entertainment of the mind. Also, in the fiction, the reader does not get out the real world to

[1] *Splash* is the English translation of *Plouf.*

join an arbitrary or fantastic world. It is the contrary. Fiction does not directly question truth or falsehood, but it is not unreal, because it cannot escape from all the constraints of the real world. Far from being an illusion, it creates a possible world that provides a playful immersion which ensures adherence of the reader (especially pupils) to the physical situation (Shaeffer, 2010). The reader makes sense of fiction only if he has some collateral experience of his world. So, this content indirectly informs us about the structure of our world. This fictional function introduces us to the modeling process. Lewis (1973), in the context of his theory of “possible worlds”, argues that there is a “comparative similarity” between the counterfactual worlds of the fiction and the real world of our experience.

In this perspective, the fictional world has a double function of involving pupils and developing their imagination: Shaeffer (2010) calls it “imaginative involvement” or “make-believe”. Shaeffer claims that the fictional narrative leads readers into the real world through the world of the pretense, so that they are able to question the real world from cognitive perspective.

Consequently, this kind of storybook plays a very important role in the epistemic construction of student’s scientific knowledge. Thus, the fiction content provides an imaginative extension of our world which can be used by the teacher. Thus, pupils can question the representative function of fiction from the underlying physical situation. It engages them into the modeling process. The Lewis’s theory of possible worlds is a relevant theoretical framework that justifies our choice to use fictional storybooks as a context for scientific inquiry in science education. It is a conceptual tool to examine “Truth in fiction” (Lewis, 1971) and truth outside the fiction and their relationships.

Cartwright (1983) argues that a “model is a work of fiction”. In this sense, model is not immediately given in the physical situation which is itself (re)constructed, but it has to be imagined and constructed by means of signs (Soudani et al., 2009). Modeling, particularly at primary school, is always controlled by the experience. Thus, using fictional storybooks with students leads them, as much as possible, to experimental reasoning which develops both imagination and manual skills, involving linking and mutual tests of hypothesis, new languages (i.e. modeling in a semiotic sense), and designing and manipulation of new experimental devices.

Epistemological issues of storybook "Plouf !": towards modeling activity

This storybook presents a fictional story that has a realistic side, otherwise it could not serve as educational tool. *Plouf* is a “realistic fictional story” which tells a story of a famished wolf. When roaming in the neighborhood of a well, he sees the moon reflection at the bottom of it. He mistakes it for some cheese. He bends and falls. He cannot go back up by himself.What can he do? A pig passes by the well. The wolf baits him and makes him using the well equipment (rope, pulley and bucket, only shown, never described verbally in the text) in order to get out of the well while the pig goes down the well. In the same manner, the pig will be delivered by rabbits who take his place. Finally, rabbits are delivered by the same wolf who finishes at the bottom of the well. Wolf and his prey pass each other by a counterweight phenomenon, and the wolf cannot catch any prey because he crosses them at high speed. Regarding physical law, the last episode is impossible, but pupils cannot perceive it. They have to be questioned about truth in this storybook.

We can consider this storybook from several points of view: First it’s playful and moral, secondly there is a scientific background about biological and physical phenomena. It develops the intelligence by means of the imagination’s development. As scientific educators and teachers, we focus on its scientific role. *The aim is to make pupils pass from superficial*

reading (playful, moral) to scientific background (well, rope, pully…). As Schaeffer (2010) said, fiction assures an imaginative implication of pupils as an integral part of the activity of scientific modeling of the perceived world. Halbwachs (1974) tells us that "*in any physical situation of the "real world", it will correspond with physical science* […] *one (or some) "signs" systems, which consist of figures, graphs, mathematical symbols, or more simple propositions formed with words. It will then be assumed that these systems will represent the situation. Such system of signs, we shall give the name of model*"*.* Modeling consists of substituting a set of signs to the material elements of the concrete situation in a way to manipulate signs instead of objects.
This requires an experimental reasoning which develops both imagination and hand skills, involving a development of relationship and mutual controls of hypotheses, signs system, designing and manipulation of new experimental devices.
Our storybook's *a priori* analysis shows that the basic steps of the modeling activity can be connected to its episodes. So, the teacher must be aware of the change in point of view, as shown in the diagram below, in order to guide pupils: 1) the first modeling stage consists of converting events of fiction into the underlying physical phenomenon. Pupils "create" signs (natural language) and use them to provoke this passage; 2) from characters register to material and physical objects register. This decisive second stage is to create other signs and use them to represent and to quantify relationships. Consequently, pupils make hypotheses about a regularity principle (law of physics). 3) In the third stage, this principle will be applied to test the coherence of the third episode.

The wolf bends: he falls into the well with the bucket	Gravity the intrigue condition = the phenomenon causality	From biological necessity (hunger) to physical action (mass and gravity)
The pig falls and the wolf goes back up	Phenomenon of the pulley: The pig is heavier than the wolf.	physical quantities and their relationships: The wolf mass (m_w), and the pig mass (m_p). $m_p>m_w$
The 3 rabbits fall and the pig goes back up	The three rabbits are heavier than the pig	$m_r>m_p$

Table1: First stage : converting fictional event

This process is a powerful way to help pupils easily modeling the physical situation of the real world: According to Lewis (1971) and to Schaeffer (2010) we can assert that modeling the world throughout fiction leads to modeling the real world.

MATERIALS AND METHODS: SEQUENCE AND DATA ANALYZED

Our goal is to provide imaginative and cognitive involvement of students and develop the thought experiments that transform the reading of the storybook into a problem solving sequence in an inquiry based approach.
We have two sets of data from sequences in two organized classes (7-8 and 5-6 years old). We reproduce below the main steps of the sequence with the 7-8 years old class, and the choices the teacher made. Each stage contains epistemological questioning that involves the modeling process. This questioning is linked to principal episodes of fictional narrative.
The teacher has a didactic choice, first by reading the whole storybook before giving any scientific explanation and then by adopting a constructivist framework. After leading an *a priori* analysis in our research group, we ask the teacher to dramatize the reading and transform the storybook into a problematic situation, in order to engage the pupils' reasoning.

Then we develop an experimental thought which compares and contrasts both fiction and reality. The goal is for the teacher to divide the story into five steps so that the pupils gradually investigate the storybooks and channel their epistemological thoughts into a modeling activity:
Step1: *Putting the story into words in order to convert the fictional events into physical phenomena. This needs specific and technical vocabulary. Like a translation, there is a need for new words to describe the phenomena.* The album has many images, but contains few words. Therefore the pupils have to design and describe, using their own words, the components of a water well, and imagine a coherent continuation for the story.
Step2**:** *Analogical modeling*. We go from formulation of hypotheses to building an analog and semiotic model. Going from characters to analogous counterparts, the pupils' task consists of conceiving, constructing and manipulating an experimental device using a rice bag, a pulley, and a rope in the classroom. This is done, so that they understand the pulley principle: by means of an artifact which is substituted for the images found in the storybook.
Step3: *Semiotic modeling*. Pupils have to construct a signs system in order to build a model (Halbwachs,1974): iconic and written symbols are required to pass from step2 to physical quantities and their relationships. They build a system of signs (as defined in Halbwachs, 1974 and Peirce, 1978) which replace the two situations (: fiction and device itself). So that students can answer this question: what conditions (*Physical Principle Formulation)* are needed to get out of the well?
Step4*: Testing validity of the model* into new problematic situations: in the storybook, how will the pig get out of the well? (Pb1), and under what conditions can the rabbits help the pig? (pb2). What mathematical and formal conditions need to exist so that the pig can get out of the well with the help of the rabbits?
Step5: *From Fiction to reality*: Is the model pertinent, verifiable, and able to be applied to other similar situations (generalization)? The teacher provokes an epistemological dialogue between pupils concerning the final image in the storybook. Can the wolf raise the rabbits? In which condition(s) is this possible? This picture contains an internal contradiction: the wolf is both heavier and lighter than himself.

We collected the data by video recordings we have transcribed. We have also collected the written productions of the pupils during their various tests. After, "E" will represent the Teacher, and "e" will represent the pupils. The extracts of dialogues in class raise(find) several episodes of debates; the numbers which follow each other belong to the same episode. Besides, involving rather of characterizing the phases of the modelling of the epistemological point of view more than the approach(initiative) of learning(apprenticeship) in a class, we did not make distinction between GS and 2nd year of primary school.

In the following, "T" is the teacher, and "E" is the students. The extracts of dialogues in the classroom are more episodes of debate, and the numbers that follow are in the same episode. Furthermore, with regard rather to characterize the phases of the modeling of epistemological point of view rather than the learning process in a class, we did not distinguish between GS and CE1.

MAIN RESULTS AND DISCUSSION

We consider step 2 of the modeling process above, in which pupils change the fictional situation (Fig.1) into a technical device in the classroom (Fig.2), by substituting an iconic sign (a drawing, Fig.3) for characters. The body of each character is replaced by the same sign (a drawing or an object that serves as a sign in order to quantify the value of their masses).

Pupils represent the mass of different characters with bags of rice that the teacher had brought in the classroom: students can then compare them in terms of “heavier/lighter”.
Another step consists of mathematizing this comparison by substituting the “*m*” alphabet sign (indicating the masses) to bags of rice, so that students can compare them in terms of “larger/smaller” or “higher/lower”, as shown in fig.4. Notion of mass –that is the common property of all physical bodies- is understood in this step, but not conceptualized by the pupils: they manipulate variables and terms of relationship.

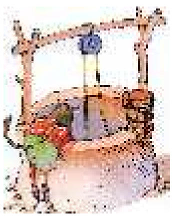

Fig1: Fictional situation

Fig2: Experimental device elaborated for the classroom: analogical model

Fig3: Narrative of a group of students, and design of the concerned device

« Experiment of Plouf !

“First, we began by doing exactly what is in the text, but there are too many of strings, so we cut some out […] and we linked it to the trestle , there were 2 bags as well, in the one there was a lot of rice, and less rice in the other. The one containing more rice was the pig, the lighter one was the wolf. Then we tried to balance them, so we removed some rice from the pig. It is the pulley which is used to help with all that”

Anaïs »

Fig3 (bis): Transcript of the explanation of a group of students (according to Figure 3). We have put in bold the key words.

Fig4: Substitution of the bags of (identified by labels) to the correspondent characters of fictional story

The following extracts of the sequence illustrate the process of connecting quantities by pupils in order to interpret the movement of involved bodies: Teacher ask them about the “apparent” contradiction in the last scene

1. Teacher: "So in your opinion, will the wolf successfully raise the rabbits out of the well?

All pupils answered “yes” (2), except one pupil who said “no”(3). But the teacher has not asked him about his response. The exchange continues as following:

4. Teacher: “Really? But how will the wolf do it?
5. Pupil 3: Well! He will pull the rope
6. Pupil 4: no, he is hanging... he doesn’t pull.
7. Pupil 5: yes, because he is big
8. Pupil 4: he is heavier than rabbits
9. Teacher: Oh! are you sure?
10. p6: yes... he will fall into the well.
11. Teacher: Okay. Then we will test with what?
12. Pupil 1: (all) the pulley !”

Pupils presuppose (wrongly?) that the wolf is heavier than rabbits. The model they have built is still used, but limited to a couple of physical quantities. On the one hand, the teacher doesn’t question the pupils about what they have learned previously. According to our *a priori* analysis, teacher might, for this last scene, guide students in developing their intra fictional reasoning. However, she chose an extra fictional criterion. On the other hand, pupils don’t spontaneously operate transitivity relationship. In defense of pupils, it should be noted that we are dealing with living things whose mass can vary over time. In this case, the relation of transitivity can be questioned.

Teacher gives each group the pulley. Pupils manipulate and observe by doing the same manner as in previous sessions. They note that:

2. Pupil 1: “The wolf [he] can not ... uh ... he doesn’t succeed in raising the rabbits out of the well”

Some pupils think that rabbits are heavier than the wolf because there are three. Others think that: (12). Pupil 4 “bah, even if they are three, [et bah] ... they can be lighter”

After the discussion, the teacher summarizes the major opinion of the class:

16. Teacher: "So, rabbits cannot be delivered by the wolf because they are heavier than the wolf, not because they are three”. She proposes “Now we'll see what happens in the story”

1. Teacher: So, in the story, how does it work?
2. Pupil 1: Bah! The wolf helps the rabbits get out.
3. Pupil 2: yes he succeeded.
4. Pupil 3: in the story, the wolf is heavier.

Then, pupils are asked to discuss the validity of the two situations: around this exchange, there is the central epistemological question for this modeling activity: what can one question? The model? The fictional situation? The empirical physical situation?

5. Teacher: “So, is it true what is happening in the story?
6. Pupil 4: No...
7. Teacher: “Really?”
8. Pupil 4: ... with the pulleys it does not work.
9. Pupil 5: This is not the same [thing in the story].
10. Teacher: So in the stories, is it always true what that is told?
11. Pupil1(all): NO!
12. Teacher: So, everything said in the stories is not always true”

Here appears a central epistemological function of modeling, which sets up a dialogue between right and wrong about a problematic situation such as in this last scene. Dialogues show that pupils are able to talk about truthful conditions and that this situation should be valid from a physical point of view.

CONCLUSION AND EDUCATIONAL IMPLICATION

On the basis of the storybook *Plouf !* as a didactic support, and the Lewis' theory of possible worlds (1978) as a theoretical framework, we tried to demonstrate that the modeling of the reality *in* fiction and the modeling of the reality *by* fiction are interdependent: modeling the physical world of the fiction leads to model the physical world of the reality.
Consequently, the theory of possible worlds would be a way to question the reality and build a model that makes the real world an application of a field of possibilities. Models, as conceived today by the philosophy of science, are a construction of a possible reality, not a copy reducing or simplifying the real world. So, they are larger and contain more things that in the observable reality, which is contingent and singular.

One consequence that seems to be interesting for the physics education is that the model created in a given situation (real or fictional) allows to consider a range of possible situations and bridges the gap between them. In other words, modeling activity is involved in the physical world and in the fictional world: It enables students to compare them, discuss them and to assess their truth.

The advantage of this modeling work for pupils would be in the development of their capacity to interpret and evaluate truth in new physical situations: intra fictional (other realistic fiction storybooks), or non-fictional (as in Blanquet, 2010, for example).

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THE RELATION BETWEEN CULTURAL BACKGROUND AND UNDERSTANDING OF PRECIPITATION AMONG 5-8 YEAR OLD CHILDREN

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Abstract: This paper presents an overview of initial results of a research line recently launched at the University College of Teacher Training in Campus of Biscay (The Basque Country) to examine whether preschool and lower grades of primary education understanding of natural phenomena (and more specifically, the mechanisms of rainwater) and, moreover, whether this comprehension differs according to the differences regarding the socio-cultural background of the children comprised in the sample (over a hundred of subjects).

Keywords: Early education, cognitive development, atmospheric phenomena.

The understanding of the mechanisms of rainfall during childhood.

Atmospheric phenomena and in particular rainfall, are widely used resources in elementary education levels for work related to both the natural sciences and metric aspects of mathematical understanding (Fernández & Rodríguez 2006 , Rossano & Schiller, 1995; Oramas, 1992, Plasencia & Varela 2006). However, the analysis of the evolving understanding of the mechanisms of rainfall during the early stages of school has received little attention, focusing the bulk of research on this subject towards students of higher educational levels (Tytler & Peterson 2004; Taiwo, Ray, Motswiri & Masen, 1999).

The few studies that have been conducted on this issue in early childhood education level show some common patterns especially related to the theme of the origin of rain. In this vein some scholars have pointed out that children tend to consider that clouds are different from water even though they accept that rain may be related to the appearance of clouds. Moreover, it has been said that children connect the sky to the generic place in which rainwater is created (Inbody, 1963, and Munn, 1974; Za'rour, 1976).

This project trys to identify and analyze the patterns of understanding of the mechanisms of precipitation at upper elementary education level (5-6 year old). Furthermore, the patterns found will be linked to the different cultural backgrounds of the children in the sample studied.

The learning process of the mechanisms of rainfall during early ages

Although the main barrier to the explanation of the mechanisms of precipitation is a lack of understanding of the concepts of the water cycle and, especially, the meaning of evaporation and condensation (Bar & Galili, 1994; Donaldson, 1973), it has been reported that these scientific concepts can be successfully taught as early as pre-school and first primary educational levels (Tytler & Peterson, 2004).

Furthermore, it has been demonstrated that early knowledge on the mechanisms that produce this rainfall is deeply influenced by the cultural framework surrounding the child, for example from cultural beliefs and pseudo-scientific knowledge plus the geographical location of the children (Miner 1992).

Moreover, what this research highlights is that from a very early age human beings try to make sense of both cultural, physical and biological phenomena that surround them. In this vein, several authors (Vosniadou, 1994, Vosniadou & Brewer, 1992) have emphasized that this cognitive attempt to make sense of the surrounding physical and cultural environment is carried out even from pre-school educational levels. Thanks to this cognitive effort children generate a way of understanding the real world which eventually provides them with a comprehensive framework which comes from the foundations of the comprehension of scientific models transmitted by scholastic learning.

Consequently, it seems reasonable that promoting a better understanding of the early interpretive models can be a useful attempt at the design of a more effective early scientific educational strategy. This could be true as bearing in mind children's explanatory contexts and new educational approaches are implemented from the child´s prior knowledge, meaning that this new knowledge will be constructed on the basis of the child´s existing knowledge (Christidou & Hatzinikida, 2006, Tytler & Peterson, 2004).

Objectives

The research presented in this paper aims to analyze how a representative sample of children at the final level of elementary education (5-6 year old) and first level of primary education (7-8 year old) understand the phenomenon of precipitation in order to detect: (a) different interpretive models (b) whether the children's cultural background and, secondary, sex and age, are related to the models displayed.

Ultimately, the main purpose of this research is to provide the field of early science education with more empirical data about how children under the age of 8 interpret very elementary concepts typically belonging to Earth Sciences. It also paves the way to the understanding of how social factors influence the grasp of these basic but indispensable notions. All these goals are thought to promote the idea of being able to design better educational proposals for elementary levels in the field of science education.

Method

The sample of the study comprises of 50 children from two public infant and primary schools located in the city of Vitoria (The Basque Country, Northeast Spain).

The age of the participants is therefore about the age of 5-6 for children at infant level and 7-8 for those who are at primary school. The sample is balanced in terms of sex ratio.

With regard to the data collection procedure, only age, sex, school and family origins were registered. The families whose children took part in the study were informed through the direction boards of the centers regarding the objectives and research methodology. The conversations with the children were recorded together with the drawings they made. No photos or video recordings were made.

A 10 minute, semi-structured interview was carried out with each of the children, using the following questions relating to the concepts to be investigated:

1. Have you ever seen rain?

2. And ... What is rain?

3. Where does rain come from?

4. How is rain formed?

5. Where does the rain go after it falls to the ground?

6. Sometimes after it rains there are puddles. Where does the water from the puddles go after it disappears?

7. Have you ever seen clouds?

8. What are clouds made of?

9. Did you notice whether clouds have always got or not, the same shape?

10. How do clouds change their form?(If applicable).

11. Do you want to tell me anything else you know about rain?

To conduct interviews and to facilitate communication with children the conversation is always initiated with a brief tale and then the researchers make use of a small puppet to encourage children to talk it regarding the aforementioned questions.

The interviews were carried out in Basque or Spanish, appropriate to the linguistic profile of the school.

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